EFFICIENCY ANALYSIS OF CEMENT INDUSTRY IN KASHMIR

Thesis submitted for the Award of the Degree of

DOCTOR OF PHILOSPHY

in

Economics

By

Syed Rizwana

Registration Number: 12116726

Supervised By

Dr Mudasir Ahmad (28134)

Department of Economics (Assistant Professor)

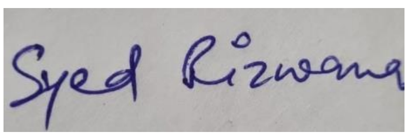
Lovely Professional University

LOVELY PROFESSIONAL UNIVERSITY, PUNJAB

2025

Declaration

I, Syed Rizwana Qadri, hereby declare that the work presented in this thesis is my original effort, carried out under the supervision of Dr. Mudasir Ahmad Dar at the Mittal School of Business, Lovely Professional University. This thesis has not been previously published or submitted to fulfil the requirements of any degree program. Any references to literature, data, or work by others have been duly acknowledged and are cited in the reference section.



Syed Rizwana

Mittal School of Business

Lovely Professional University

Phagwara, Punjab.

Certificate

This is to certify that the thesis titled "Efficiency Analysis of the Cement Industry in Kashmir" has been conducted by Ms. Syed Rizwana, a Ph.D. research scholar at Lovely Professional University, under my supervision and guidance. This thesis is submitted by her as part of the requirements for the degree of Doctor of Philosophy degree in Economics from Lovely Professional University. The thesis is her original work and is deemed worthy of consideration for the Doctor of Philosophy degree.

Dr Mudasir Ahmad
Assistant Professor
Mittal School of Business
Lovely Professional University
Phagwara, Punjab

Abstract

The cement business is essential for fostering a nation's economic growth and development Uddin et, al, 2023; Uratani et, al, 2023. It assists as the essential building module imperative for any construction project, making it vital to the whole construction process Mishra et, al, 2022; Ren et, al, 2023. As of 2024, India holds the position of the second-largest cement producer internationally. Dhar et, al, 2020 with a potential to generate around 500 million tonnes of cement annually Indian Brand Equity Foundation, 2023. The industry is predicted to continue growing at a rapid pace due to the Indian government's commitment on infrastructure development, making it an important part of the country's economy Singh 2021; Mudghal & chellasamy, 2024. The cement industry's overall competitiveness and sustainability are significantly influenced by its economic efficiency EI Salamony et, al 2020; Adhikary, 2024. It shows how well the sector can minimize expenses while maximizing production from a given set of inputs, such as labor, capital, and raw materials Mookhtar & Nasooti 2020; Kukreja et, al, 2023.

Financial viability of individual businesses and the sector's impact on the whole economy both depend on economic efficiency Li Z & Liu H, 2022; Wang et, al, 2023. A company's economic efficiency can be thought of as consisting of two primary parts. The firm's ability to maximize output from a given set of resources is referred to as technical efficiency. Allocative efficiency refers to a firm's capability to maximize profits by aligning the marginal revenue product with the marginal cost of inputs "Gu et, al, 2021; li et, al, 2021; Hao et, al, 2023". It makes sense to believe that different approaches to applying input could result in different output outcomes "Miernyk, 2020; Узі, З., & Сотник, І. (2023)". In other words, given a comparable set of inputs and technology, a company that employs the best practice method produces the highest possible output, which is superior to a company that does not do the same Hewings G, 2020; Semenova & Martinez, 2023.

According to reports, universal cement production surpassed the International Energy Agency's (IEA) 2050 forecast by reaching 4.4 billion tons in 2022 An et al., 2019. However, large-scale production is associated with high energy consumption, the generation of industrial solid waste, flue gas emissions, and eventually environmental degradation Summerbell et al., 2016. Due to its

significant consumption levels, the cement industry is responsible for approximately 5% of global greenhouse gas (GHG) emissions, second only to the steel industry in global emanations Ravindra, 2021. Cement industries in Asia, particularly in China and India, are leading contributors to both global production and environmental pollution (ICR, 2018).

It is essential to comprehend the three separate dimensions “economic, environmental, and social” as well as how they interact. Nonetheless, there hasn't been much focus on the social dimension in the literature “Fahimeh et, al 2023; Jian et, al 2014; Mani et, al 2016”. whereas the bulk of research focuses on wealthy nations “Carter and Jennings, 2002, 2004; Gunasekaran and Spallanzani, 2012; Pinar et al., 2014”. Aside from a small number of research, in underdeveloped nations and emerging economies “Chaves et, al 2021; Sangwan et, al 2019” research on cement industry social sustainability (CISS) is scarce. Social sustainability, which highlights the critical significance of inclusivity, ethical behavior, and community well-being, is a key component of long-term success in the cement industry (Rodrigues,2011). The industry can establish positive relationships with its surroundings by prioritizing health and safety standards, actively engaging with local communities, and offering employment opportunities (Rasmi & Turkay, 2023). Sustainable and peaceful coexistence is facilitated by stakeholder collaboration, environmental justice principles, and moral business conduct. In the cement industry, social sustainability is not only a corporate responsibility but also a strategic imperative that builds credibility, trust, and long-term resilience (Nidheesh & Kumar 2019).

The cement industry contributes significantly to global environmental challenges by making up a sizeable portion of carbon dioxide emissions worldwide Zhang et, al, 2008. Policies for sustainable development are therefore essential to reducing the sector's negative environmental effects Duque et, al, 2022. These regulations promote the use of environmentally friendly methods, like cutting back on energy use, switching to alternate raw materials and fuels, and implementing carbon capture and storage system. Governments and industry stakeholders can collaborate to lower greenhouse gas emissions and mitigate the effects of climate change Wu & Wang, 2004, and encourage the switch to a further environmentally sustainable cement construction procedure by enforcing regulations and offering incentives to promote sustainable practices.

Furthermore, social and economic aspects are also taken into account by sustainable development policies in the cement industry, in addition to environmental ones. Socially, by addressing issues with noise pollution, land use, and air and water pollution, these policies put the welfare of the communities residing close to cement plants first Brechin et, al, 2003. In order to guarantee that local communities are involved in decision-making processes pertaining to cement production activities, they also stress the significance of stakeholder engagement Ighalo & Adeniyi, 2020. In terms of the economy, policies for sustainable development encourage efficiency and innovation in the industry Joshi & Smith., 2002. which drives investments in the study and development of greener technologies and stimulates employment growth. Sustainable development policies in the cement industry aim to strike a balance between social responsibility, profitability, and environmental stewardship by combining environmental, social, and economic goals.

Objectives of the Study:

- To assess the economic efficiency of cement industry in Kashmir.
- To analyze the impact of cement industry on the environment in Kashmir.
- To evaluate the social efficiency of cement industry in Kashmir.
- To evaluate the role of government policies in the sustainability of cement industry in Kashmir

Hypothesis of Study

Objective 1

- (H0): There are no significant variations in the economic efficiency of cement plants in Kashmir, regardless of technology adoption or resource management practices.
- (H1): There are significant variations in the economic efficiency of cement plants in Kashmir, with those adopting advanced technologies and optimized resource management practices demonstrating higher productivity.

Objective 2

- (H0): The cement industry in Kashmir does not significantly impact the air quality in regions like Khrew and Khanmoh, and particulate matter (PM10) levels do not exceed environmental safety standards.
- (H1): The cement industry in Kashmir significantly impacts the air quality in regions like Khrew and Khanmoh, with particulate matter (PM10) levels exceeding environmental safety standards and contributing to adverse public health outcomes.

Objective 3

- (H0): The cement industry in Kashmir does not experience significant issues related to labor welfare, and occupational health, safety measures, and labor conditions do not negatively affect worker satisfaction or productivity.
- (H1): The cement industry in Kashmir experiences significant issues related to labor welfare, with inadequate occupational health, safety measures, and labor conditions negatively affecting worker satisfaction and productivity.
- **Objective 4**
- (H0a): There is no significant association between demographic factors (age, gender, occupation) and awareness of policies (NCAP, Occupational Health and Safety, and Minimum Wage).
- (H1b): There is a significant association between demographic factors (age, gender, occupation) and awareness of policies (NCAP, Occupational Health and Safety, and Minimum Wage).
- (H0c): Government policies such as the Minimum Wage Policy (MWP), Occupational Health and Safety (OHS) regulations, and the National Clean Air Programme (NCAP) are consistently and effectively implemented across all cement plants in Kashmir, without significant variation in compliance.
- (H1d): Government policies such as the Minimum Wage Policy (MWP), Occupational Health and Safety (OHS) regulations, and the National Clean Air Program (NCAP) are not consistently implemented, and there is significant variation in policy compliance across cement plants in Kashmir.

Research Design:

In order to achieve its goals, this study uses a mixed-method research methodology that incorporates primary and secondary data. The economic, environmental, and social effectiveness of Kashmir's cement industry is evaluated, along with the influence of government policies on the industry's sustainability, through the application of quantitative methods. Depending on the type of data and the purpose of the investigation, each of the four main objectives of the study uses a different set of statistical tools and procedures.

Secondary data from 2021 to 2023 is used for the first objective, which evaluates the economic effectiveness of the cement sector in Kashmir. Nine cement factories in the region are evaluated for efficiency and productivity increases using the MPI and DEA. A thorough comparison of plant efficiency over time is possible with these techniques. The DEA and MPI are computed using R software, which allows for a thorough examination of resource management and operational effectiveness throughout the facilities.

The second goal looks at how the cement industry affects the environment. It uses primary data from air quality monitoring in the Khrew and Khanmoh areas of Kashmir, specifically looking at PM10 levels between 2014 and 2023. Using regression analysis and SPSS software, the relationship between cement production and deteriorating air quality is examined. Furthermore, the AQI is computed to monitor changes in ambient pollution, offering information on seasonal fluctuations in pollution and how they relate to industrial operations.

Secondary data is once more employed for the third aim, which assesses the social efficiency of the cement sector. This data is mostly taken from survey reports and employee input regarding labor practices, working conditions, and health and safety procedures. While EFA and CFA are carried out using SPSS and AMOS software to discover the important factors affecting labor welfare and work satisfaction, descriptive statistics are used in the study to summarize the data. These techniques aid in the comprehension of the hidden factors influencing social efficiency in cement manufacturing facilities.

The fourth aim uses primary data from policy compliance reports and field surveys to evaluate how well government regulations ensure the sustainability of the cement industry in Kashmir. The study used chi-square tests to determine the statistical significance of the patterns in policy implementation across several plants and cross-tabulation to find trends in these implementations. These analyses, which shed light on the efficacy of laws like the NCAP, the OHS rules, and MWP, are carried out using STATA software.

Conclusion:

This study gives a detailed assessment and analysis of the cement manufacturing industry in the Kashmir region, in terms of its economic impacts, environmental concerns and social issues, as well as the regulations affecting it. It captures the issues and prospects that characterize the industry and provides a framework on the optimization and resilience of the industry.

Analyzing nine cement plants, the assessment of the economic situation gives a picture of the development of productivity in the sector for 2021-2023. While the overall industry only had a 4.1% annual growth rate, there were large differences between various specific firms. Albeit some firms: for instance, Khyber Cement, boosted technological advancement and Pragmatic managerial policies following which they have recorded a fabulous 74 % productivity improvement. On the other hand, most enterprises such as TCI and Valley Cement experienced a negative trend in productivity mainly because of scale diseconomies and technology lock-ins. They provide strong evidence for the proposition that sustained innovation, efficient resource utilization and scale are paramount as industry players strive to retain competitiveness and efficiency in the industry.

The environmental effects have been observed concerning the cement industry in the Kashmir area nonetheless the cement sectors in both Khrew and Khanmoh regions have emitted environmental air quality for many years. Moderate changes in the figures were detected with relatively better pollution control measures in 2019 with oscillatory variations observed in the three years 2016,2019 and 2020. Other factors peculiar to the location likewise had surfaced – enhanced pollution during summer and winter depending on the place. The dire consequences on health, for instance, increased incidences of respiratory ailments like bronchitis and asthma, compel the argument for a targeted green approach to the region. These issues can be well solved not only by enhancing the related technologies but also by improving the cooperation among industries, regulatory bodies and local communities.

From a social perspective, the study offers important knowledge on working conditions in cement factories in Kashmir. Despite some level of improvement in worker health and safety there are issues that have raised concerns such as lack of standard in occupational safety dimension, and unfair treatment of workers. Employees complained loud and clear about remuneration and recognized the fact that they are not compensated fairly for the risks they take. Problems of promotion, biased, and discriminations were also raised, which showed inefficiency in management practices and requirement of friendly work atmosphere to embrace all. Improve system cooperation in the industry is important for creating a better and happier staff, which leads to greater organizational effectiveness. Government policies thus play a significant role determining sustainability and compliance issues affecting the cement industry. Hypotheses tested included the level of compliance with the MWP, OHS, and NCAP. However, several related socioeconomic factors remained inconsequential in defining the level of policy compliance and the presence of cement plants did not guarantee superior levels of compliance. This brings out the need for more stringent regulatory measures, policy awareness and cross-sectional policy enforcement measures. Training sessions, updated communication and awareness tools together with mutual cooperation between the regulators and the industries can lead to enhanced standard and compliance, occupational health and safety and environmental stewardship.

Therefore, it is pointed out in this study that the cement manufacturing sector in the context of Kashmir is laden with specific issues socio-economic and others having to do with the environment and the society. Solving these problems is possible only through using technological solutions, protecting the environment and increasing employment rates, including the use of reasonable measures by the government. In this way the industry will be able to increase its productivity and thus its competiveness while at the same time maintain sustainability and a high level of social responsibility. From this study, relevant recommendations can be made to policymakers, industry stakeholders and other relevant decision makers to enhance the industry for the benefit of all those involved and in the region.

Limitations of Study:

Although this study offers insightful information about the social, political, environmental, and economic aspects of Kashmir's cement business, it is not without flaws:

- **Data Availability and Quality:** The research utilized a combination of primary and secondary data although there were limitations on the data's trustworthiness and availability, especially for the economic and environmental analyses. While real-time changes in cement plant operations may not be entirely captured by secondary data, irregular monitoring of air quality may result in gaps in the data.

- **Geographical Scope:** The study is restricted to cement plants located in the Kashmir region, which may not be a complete representation of the sector worldwide or in other regions of India. The conclusions, therefore, may not apply to other areas and are limited to the socioeconomic and environmental circumstances of Kashmir.
- **Time Frame:** The years 2021–2023 are the subject of the economic analysis. Long-term trends and the effects of outside variables, such as modifications to the dynamics of the global market, advancements in technology, or changes in regulation, may not be completely captured by this little time period, which could have an impact on future plant efficiency or environmental performance.
- **Limited focus on Qualitative Insights:** The study heavily relies on quantitative techniques such as DEA, MPI, and regression analysis, but it pays little attention to qualitative perspectives, especially when it comes to labour welfare and policy implementation. Extensive interviews or case studies may yield a more comprehensive comprehension of the social dynamics within the industry.
- **Technology and policy Impact:** The study looks at how government policies and technology might improve sustainability, but it doesn't completely address how local operations might be impacted by external market forces or changes in global regulations because of how complicated it is to adopt new technologies and apply legislation.
- **Regional Environmental Factors:** The environmental analysis, in particular the PM10 levels research, might not fully take into consideration regional or other pollutants that could significantly affect air quality, like seasonal agricultural operations or vehicle emissions. Therefore, it might be oversimplified to fully blame the cement sector for the levels of pollution.
- **Policy Compliance Measurement:** Although policy compliance is assessed using chi-square and cross-tabulation tests, the study makes the assumption that there is a linear relationship between the existence of policies and their execution, failing to properly account for the influence of informal practices or issues with local governance on compliance.

ACKNOWLEDGEMENT

فَإِنَّ مَعَ الْعُسْرِ يُسْرًا إِنَّ مَعَ الْعُسْرِ يُسْرًا

“Undoubtedly, along with hardship there is ease” (The Qur’an, 94:6)

I would like to acknowledge people whose continuous assistance and contribution ultimately became the sole determinant in the completion of this thesis. Without their selfless efforts and blessings, the realization of this work would not have been possible. Many people have influenced this research work and I am not in a position to list them all.

First and foremost, I must acknowledge my thanks to **Almighty Allah** for countless blessings that he has showered upon me and without grace, mercy and pleasure I could not have completed this thesis. My humblest gratitude to the **Prophet Muhammad** (Peace be upon him) whose teachings has been continuous guidance throughout my life.

A Ph.D. is more than just a degree; it’s a journey that requires immense self-motivation and determination. However, above all, it demands the unwavering efforts of a guide. Fortunate are those scholars who have a mentor that not only imparts knowledge but also helps shape their overall personality. I count myself among the lucky ones. I would like to express my heartfelt gratitude to my esteemed guide, **Dr. Mudasir Ah. Dar**, Professor at the Mittal School of Business, Lovely Professional University. I am deeply indebted to him, as this research would not have materialized into a thesis without his tireless support and guidance.

I would like to extend my heartfelt gratitude to **Dr. Rajesh Verma**, Professor and Head of the Mittal School of Business, for his unwavering support and for providing us with every necessary facility. His guidance and encouragement have been instrumental throughout this journey

I extend my sincere thanks to **Dr. Pooja Kansara, Dr Asif Ali Bhat, Dr Tanima Datta, Dr Firdous Ah. Malik** and to all the panel members for their insightful suggestions during this research work.

The Ph.D. journey blesses you with relationships that are cherished for a lifetime. These companions, friends, or sometimes called "angels," stand by you through the ups and downs, sharing every possible experience until the joyful conclusion. I am delighted to acknowledge **Syed Kamran Haqqani, Dr Syed Ulfat Andrabi, Dr Aliya Ashraf, Dr Mohsin Showkat, , Dr Syed Khalid, Laiba Anwar, Farhat Jahan, Noor un nisa, Ankit Kumari, Peerzada Dr Obaid, Dr Manpreet Kailey, Dr Muzammil Rahman and Dr Basit Ahmad** for their support throughout.

The Ph.D. journey challenges an individual on academic, emotional, and financial fronts, yet it also offers the opportunity to appreciate and express gratitude to those who matter most. Words are not enough to convey how deeply grateful I am to my siblings "**Syed Sumaiya Qadri, Syed Tazaka Qadri, and Syed Murtaza Qadri**". Their unwavering support, understanding, and love have been my constant source of strength. They have stood by me through every struggle, offering encouragement and keeping me grounded when things felt overwhelming. I am truly blessed to have them by my side, and this achievement is as much theirs as it is mine.

Finally, I offer my deepest and most heartfelt thanks to my parents, **Mr. Syed Tariq Hussain Qadri and Syed Mahmooda Geelani,** the people I admire the most. No words can truly capture the immense gratitude I hold in my heart for both of you. You are the foundation of my life, the most essential, critical, and irreplaceable presence in everything I do. I could never have become who I am today without your constant love, support, and unwavering devotion.

Abu, you have stood by me through the toughest times, lifting me up when I needed it most, and celebrated my achievements with joy and pride. There is no way I could ever repay you for everything you have done for me, but I promise to always be by your side, as you have been by mine**. Mumma**, your love, sacrifices, and prayers have been my guiding light throughout this journey. I am forever indebted to you both, and everything I achieve is a testament to your belief in me.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AQI	Air Quality Index
AAQ	Ambient Air Quality
AVE	Average Variance Extracted
CCS	Capture & Storage
CKD	Cement Kiln Dust
CISE	Cement Industry Social Efficiency
CMA	Cement Manufacturing Association
CO2	Carbon Dioxide
CO	Carbon Monoxide
CCR	Charnes Cooper & Rhodes
CRS	Constant Returns to Scale
CPCB	Central Pollution Control Board
CSR	Corporate Social Responsibility
CFI	Confirmatory Factor Analysis
CFI	Confirmatory Fit Index
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
DGMS	Director General of Mines Safety

EFA	Exploratory Factor Analysis
EPA	Environment Protection Authrity
EIA	Environmental Impact Assessment
ECS	Extra Cellular Polysaccharide
FLSA	Fair Labor Standard Act
FL	Fair Labor
GDP	Gross Domestic Product
GHG	Green House Gas
GIS	Graphical Information System
GFI	Goodness of Fit Index
ILO	International Labor Organization
IBEF	Indian Brand Equity Foundation
LCIA	Life Cycle Impact Assessment
MSV	Maximum Shared Variance
MOEFCC	Ministry of Environment, forests, and Climate Change
MWP	Minimum Wage policy
MPI	Malmquist Productivity Index
NCAP	National Clean Air Programme
NAAQ	National Ambient Air Quality
NOX	Nitrogen Oxide
NCR	National Capital Region
OHS	Occupational Health & Safety
OPC	Ordinary Portland Cement
PM	Particulate Matter
PPC	Portland Pozzolana Cement
PCA	Principal Component Analysis
RSPM	Respirable suspended Particulate Matter
RMSEA	Root Mean Square Approximation
SPM	Suspended Particulate Matter
SOX	Sulphur Oxides

SE	Scale Efficiency
SPSS	Statistical Package for Social Science
SFA	Stochastic Frontier Analysis
TSP	Total Suspended Particles
TFP	Total Factor Productivity
TCI	Trumboo Cement Industry
UNICEM	United Cement Company of Nigera
UT	Union Territory
VOC	Volatile Organic Compounds
WHS	Workers Health & Safety
WCED	World Commission on Environment & Development
WBCD	World Business council for Sustainable Development

Chapter I

Introduction:

1.1 Back ground of Cement industry

The term opus caementicium, which means chipped rock fragments, was used in Ancient Rome to describe construction that resembled modern tangible and was constructed from crumpled rock with burnt lime as a binder. This is where the word "cement" first appeared. Leeds-born mason “Joseph Aspdin” heated ground clay and limestone until the limestone calcified in 1824 (World Cement Association). He then ground the combination once more and noted that the mixture set after some time when water was added. Aspdin termed his discovery "Portland Cement" because of its likeness to the rock produced from quarries on the "Island of Portland on the British Coast," and its use became common in the construction of structures in England. Wang et al., 2023.

Cement manufacturing has significantly evolved since its inception over 2000 years ago. Although the utilisation of cement in concrete has a long-standing history, the industrial production of cements commenced in the mid-19th century (Huang et al., 2023). Shaft kilns were initially employed in the process; however, rotary kilns ultimately became the global industrial standard. Global cement output has attained 2.8 billion metric tonnes per year and is anticipated to exceed 4 billion metric tonnes annually. Yin et al., 2024. Substantial growth is expected in nations like China, and India, as well as in regions including the Middle East and North Africa. Masmali, 2021.

1.2 Global overview of Cement Industry: One of the most essential building materials in the world is cement. It is mostly utilised to make concrete. Sand, gravel, crushed stones, cement, and inert mineral aggregates are the main components of concrete. Due to the importance of its products to the construction sector and to the country's gross domestic product, the cement industry is crucial to the global economy. Ahmad et al., 2021. Over the past two decades, there has been a rapid and exponential increase in the demand for cement and concrete on a global scale due to a number of significant, ongoing trends, including the rising population and the rising demand for infrastructure and housing (Amran et al., 2022). As a result, this need has been met by expanding cement facilities, increasing raw material extraction, consuming more fossil fuels, and having a negative influence on the environment (Gupta et al., 2020).

There is no doubt that the building business is very important economically. It is challenging to calculate the influence on the economy. Extremely high rates and volumes of cement production and consumption are seen in Uratani & Griffiths, 2023. Cement is never used on its own, though. For instance, numerous more resources and economic sectors are needed to construct a typical structure. Many materials are required, including, but not limited to, sand, rocks, steel, aluminium, gypsum, glasses, and polymers. Kunche & Mielczarek, 2021.

The perils of climate change are a significant environmental concern confronting our society. Carbon dioxide (CO2) is a principal greenhouse gas. Kajaste and Hurme (2016). Fossil fuel combustion, deforestation, unsustainable biomass burning, and the emission of mineral-derived CO2 are all examples of anthropogenic sources of CO2. Benhilal et al., 2022. The production of cement increases CO2 emissions due to fossil fuel combustion and limestone decarbonisation. Cement production necessitates significant energy consumption. The cement industry accounts for about 2% of global primary energy usage, which is nearly 5% of overall industrial energy consumption. The global annual demand for cement is approximately 4 billion metric tonnes. According to Abdul et al. (2021), this is about equivalent to the addition of 4 billion tonnes of CO2 to the atmosphere. Marmier, 2023.

Around the world, the cement industry has frequently used anti-dumping laws. WTO regulations played a key role in resolving conflicts between domestic manufacturers and international companies charged with lowering prices Fan& Zhang, 2004. Anti-dumping laws were frequently employed by developing nations to shield their own cement sectors from big, foreign companies OECD, 2003. Emphasises how trade practices and competitiveness in the cement industry are impacted by the WTO's legal framework. China's entry into the WTO improved market access and competitiveness Ramesh Chand, 2006. After the admission, cement exports rose. Reforms at home increased productivity and drew in foreign capital. The study uses a dynamic disequilibrium adjustment model to examine the possible impacts of Iran's WTO entry on its cement sector P. Bown, 2008. It implies that joining the WTO would result in more competition and call for structural changes in the sector. The study looks at how Laos's WTO membership has affected its steel bar, cement, and brewing sectors WTO Report, 2011. It concludes that reducing tradable input tariffs may boost the cement industry's effective rate of protection and, consequently, its competitiveness Montague J Lord, 2018.

Fossil fuel combustion is the primary energy source for cement production. The production of cement is expected to increase further in the coming years due to economic growth and escalating urbanization in developing countries (Deja et al., 2010). Cement serves as a crucial binding agent in mortar and concrete, employed worldwide as an essential construction material. In ancient Rome and Greece, the history of cement began about 2,000 years ago with the amalgamation of lime, volcanic ash, and water to produce a binder. Singh and Middendorf (2023) Cement production currently uses lime, silica, alumina, and various mineral constituents as raw ingredients. A rotary kiln grinds, mixes, and heats this combination at elevated temperatures to produce clinker, an intermediate product. The cement is subsequently processed into a fine powder and mixed with gypsum to produce cement. Sahoo and Kumar (2022)

Projections indicate that the global cement market is expected to grow at a compound annual growth rate (CAGR) of 5.1%, increasing from $340.61 billion in 2022 to $481.73 billion by 2029 (Henry J., 1967). The demand for residential buildings has risen in line with population growth, leading to an overall increase in global cement demand. Additionally, the growing need for public infrastructure and non-residential buildings, such as hospitals and facilities in the healthcare sector, has created opportunities for product consumption. Consequently, current market trends show an upward demand from the expanding construction sector (Sagar, 2023).

1.2 Cement Industry in India: In 1914, India Cement Company Limited established the inaugural cement factory in Porbandar, Gujarat. Prior to that, in 1904, a company named South India Industrial Ltd. established a modest cement factory in Madras (Balsara & Jain, 2021). Two more cement facilities followed, one in Lakheri, Rajasthan, and the other in Katni, Madhya Pradesh. The British Standard Committee designated India Cement Company Ltd.'s cement as "Artificial Portland Cement." This enterprise achieved financial success by promoting its products in Mumbai, Karachi, Madras, and other regions. At the time of the Cement Manufacturing Association (CMA), India was required to import cement from England. The imported cement was more expensive. It rapidly gained significance in India owing to several variables, including increased domestic demand, reduced foreign supply (attributable to war), the availability of Indian capital, a surplus of raw materials, inexpensive labour, governmental assistance, and others. Dasgupta and Das (2021). The cement industry experienced a significant enhancement due to World War I, leading to the establishment of six new facilities in 1922–1923, with a production capacity of 559,000 metric tonnes.

Cement manufacturers founded the "Cement Manufacturers Association" as their first organization in 1925. In 1927, the "Concrete Association of India" followed. In 1930, the "Cement Marketing Company of India" established a quota system based on the installed capacity of its factories. With the exception of Sone Valley Portland Cement Company, all of the cement companies came together in 1936 to form Associated Cement Companies Ltd. (ACC). According to Ravi & Nallanavar (2014), this was the most significant event in the history of the cement industry in India. The ensuing years saw the establishment of numerous additional businesses. India possessed 24 factories prior to partition, of which it kept 19, producing 2.1 million metric tonnes annually. India faced a problem in demand as production dropped from 2.7 MT to 2.1 MT, while Pakistan faced a problem in supply as it struggled to dispose of the cement produced (CMA).

The cement industry experienced a significant enhancement due to World War I, leading to the establishment of six new facilities in 1922–1923 with a production capacity of 559,000 metric tonnes. Gupta et al., 2020. In 1934, there were approximately 11 cement companies, 10 of which merged to establish Associated Cement Co. Ltd. Founded in 1937, the Dalmia Cement Group built facilities in Punjab, Tamil Nadu, and Bihar. By 1947, there were 18 cement mills with an impressive installed capacity of 2.15 million metric tonnes. The nation's advancement in sustainable growth and economic development is significantly reliant on the cement sector. Cement is essential for the construction industry and many infrastructure initiatives (Gupta et al. 2015). The construction sector contributes only 7% of the nation's gross domestic product (GDP). The industry has a significant impact on the Indian economy because of its strong connections with sectors such as coal, power, transportation, and building.

India is the world's second-largest producer of premium cement. There are over 365 small cement plants and 183 large cement plants in India. Currently, 40 companies across the country are involved in the cement market, as reported by Pareekh & Sankhala in 2021. The cement industry in India is flourishing as a result of the nation's general economic growth. Since it is derived, the main factors affecting the demand for cement are investments in infrastructure, construction projects, industrial activities, and real estate. Paswan, 2021. The cement industry's primary economic contribution to India is employment. The cement industry is experiencing tremendous growth due to the Indian economy's general expansion. This growth is primarily attributable to increased industrial, real estate, and construction activity, as well as increased investment in infrastructure sector consolidation in the coming years. Chauhan et al., 2021. The industry sustains over 0.14 million jobs, contributes 1.3% to the GDP, and has earned recognition as a core sector. Moreover, the industry makes a significant contribution to the excise and sales taxes provided to the federal, state, and local governments (IBEF).

1.4 Types of Cement:

1.4.1 Ordinary Portland Cement (OPC): Regular Portland cement is the utmost popular type of cement produced and used globally. The term "Portland" refers to a type of building stone mined in Dorset, England's Isle of Portland. OPC also serves as a raw material for grout, wall putty, solid concrete blocks, AAC blocks, and various cement types.

1.4.2: Portland Pozzolona Cement (PPC): Mixing pozzolanic clinker with standard Portland cement, often using gypsum or calcium sulphate, produces Portland pozzolana cement. Compared to OPC, it exhibits greater resistance to various chemical reactions occurring in concrete. Underwater concrete applications, such as bridges, piers, dams, marine structures, and sewage systems, commonly use PPC.

1.4.3: Rapid hardening Cement: Contractors and construction teams choose rapid-hardening cement due to its significant early strength while curing. Its strength after three days is comparable to that of ordinary Portland cement (OPC) after seven days, given an identical water-to-cement ratio. Both a more refined grinding process and an increased lime concentration are responsible for the accelerated strength development. Projects that prioritize the rapid removal of formwork, cost reduction, and abbreviated construction timelines often utilize this type of cement.

1.4.4: Extra Rapid Hardening Cement ERHC cures and solidifies more swiftly than ordinary Portland cement and rapid-hardening cement. Buildings accomplish this by incorporating calcium chloride into the rapid-setting cement. Its quick setting makes it ideal for concrete projects in cold environments.

1.4.5: Quick Setting Cement: This concrete variant may cure and gain strength more rapidly than ordinary Portland cement and rapid-hardening cement, akin to extra-rapid-hardening cement. It solidifies more rapidly than OPC, however, and possesses a comparable grain structure and strength rate. Rapid-setting cement may be advantageous for projects that require expedited completion or are located near flowing or still water.

1.4.6: Low Heat Cement: Producers monitor the tricalcium aluminate content in the mixture to ensure that it remains below 6% for low-heat cement production. This form of cement has reduced sensitivity and enhanced resilience to sulphates compared to other varieties, owing to its capacity to sustain low heat during the hydration process. It may be suitable for extensive concrete construction or projects where thermal cracking is a concern. Conversely, low-heat cement may require a longer setting time compared to other types.

1.4.7: Sulphate resisting Cement: Utilizing sulphate-resistant cement is a practical method to mitigate the detrimental effects of sulphate exposure on concrete. Building foundations commonly use it in sulphate-rich soils. We use this specific concrete for retaining walls, culverts, canal linings, and other structures that might come into contact with sulphates. This type of cement can significantly reduce the risk of sulphate-induced damage to concrete structures in challenging environments for builders.

1.4.8: Blast Furnace Slag Cement: Manufacturers grind clinker with up to 60% slag in order to create blast furnace slag cement. As a result, they produce cement that shares many characteristics with OPC. But compared to other types, it might be less costly to produce, which makes it a beneficial option for projects with tight budgets.

1.4.9: High Alumina Cement: Mixing bauxite and lime, then grinding the mixture with clinker, produces a fast-setting variety of cement known as high-alumina. This cement has a higher compressive strength and may also be more flexible and workable (OPC) than regular Portland cement. High-alumina cement is beneficial for construction projects that must withstand tough weather conditions, such as intense heat or freezing temperatures. Because of its unique characteristics, it is particularly well suited for applications where durability in harsh climates and quick setting are critical.

1.4.10: White Cement: WC is one variety of OPC that is white rather than grey**.** It might cost more than other forms of cement because it is made from raw materials without iron oxide. It is frequently helpful in architectural projects as well as decorative projects both inside and outside, such as creating floors, garden paths, swimming pools, and decorative concrete products.

1.4.11: Coloured Cement: White cement and OPC are comparable to the characteristics of coloured cement. To get the right colour, manufacturers combine OPC with mineral pigments at a ratio of 5% to 10%. Contractors frequently use this type of cement, similar to white cement, for projects that enhance their designs and for decorative purposes.

1.4.12: Air Entraining Cement: When compared to conventional Portland cement (OPC) and other cement types, air-entraining cement offers better workability at lower water-to-cement ratios. We grind air-entraining additives like resins, adhesives, and sodium salts into the clinker to create this speciality cement. Air-entraining cement is very useful in cold environment construction because its main use is in the creation of frost-resistant concrete. Because of its special composition, it performs better in harsh environmental settings while keeping the desired workability qualities.

1.4.13: Expansive Cement: Expansive cement, in contrast to ordinary cements, maintains its volume during the curing process and may even slightly enlarge over time. It differs from traditional cement types in that it does not shrink during the hardening process, thanks to this special quality. For tasks like grouting anchor bolts or concrete ducts, it might be useful. Teams can also use it to reinforce other concrete structures or in structural joints.

1.4.14: Hydrographic Cement: Chemicals that repel water combine to create hydrographic cement. In addition to being very strong and workable, this type of cement deters water, preventing weather damage. Teams working on projects like water tanks, spillways, dams, and water-retaining structures can use hydrographic cement.

1.4.15: Portland Limestone Cement: A mixture of 5% to 15% fine limestone and Portland cement is known as Portland limestone cement. For general use, its qualities are comparable to those of Portland cement. But it also emits about 10% less greenhouse gas, which can contribute to greater sustainability.

1.5 Cement Industry in Kashmir: An Overview

The northern Indian Union territory of Jammu and Kashmir's economy is based mostly on tourism, although it also has a thriving manufacturing and industrial sector. The Government of India has given unique motivations in the form of tax breaks to entice investment in the industrial sector in states with a low level of industrialisation, such as Utarakhand, Himachal Pradesh, Jammu and Kashmir, etc. (Mehraj et al. 2013). In order to make Jammu & Kashmir an independent state, the government has been allocating more money to this industrial hub. Significant and diverse mineral reserves exist in all of Jammu and Kashmir's districts. Various minerals, such as “coal, lignite, bauxite, limestone, and gypsum” among others, possess potential for utilisation in marketable applications Ashraf & Balla, 2018.

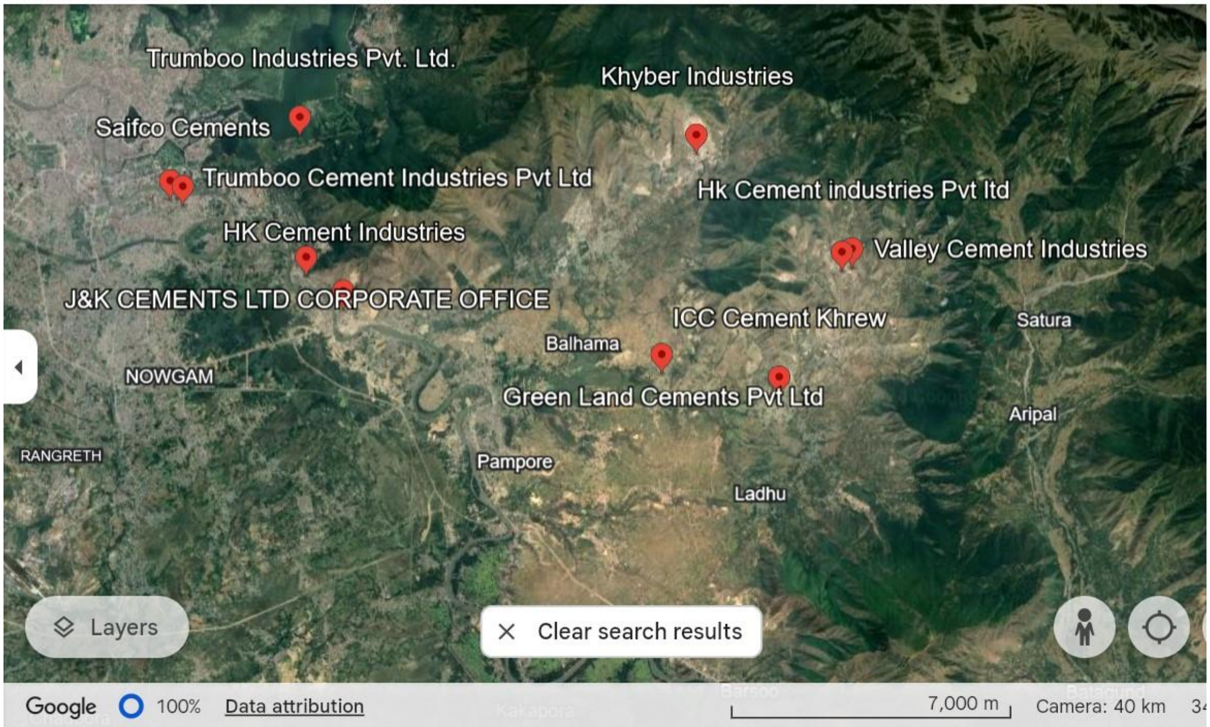
The cement industry in Kashmir, which is part of the greater Jammu and Kashmir union territory in India, has fully-fledged gradually over the years. Natural resources in the region, such as limestone and gypsum, have played a critical role in the establishment of cement manufacturing operations (Dar & GH 2006). Kashmir's cement industry has been around for several decades. Localities such as Khrew and Khonmoh 6790 saw the construction of early cement production plants; today, these locations are home to nine operational cement plants. (Mansoor et al. 2020). The region is rich in limestone, a crucial raw ingredient in cement production. We mine limestone, process it into clinker, and then pulverize it into cement (Shakeel et al. 2015). The availability of resources has been a critical factor in the cement industry's growth. In Kashmir, the installation of cement facilities has aided industrial growth and job creation (Ashraf & Bhat, 2013). These plants not only manufacture cement for local construction needs, but they also subsidise to the area's general economic development. A variety of infrastructure projects, including the construction of buildings, roads, bridges, and other vital structures, use Kashmir cement. This aids in the general growth of the region's infrastructure. Corresponding any other industry, the cement industry has experienced regulatory compliance, environmental issues, and market swings. A priority has been to balance industrial growth with environmental sustainability. According to the department of geology and mining, nine plants are operating in Kashmir, located in the Khrew and Khanmoh areas of Pulwama. Three plants—Khyber, TCI, and Saifco—are located in Khanmoh, and the rest are in Khrew.

Table 1.1 Operational Cement plants in Kashmir:

S. No.	**Name of Mine**	**Location village & district**	**Area (Hectare)**
01	M/S Khyber industries	Tulpaw village Khanmoh, **District, Srinagar**	77.96 ha
02	M/S Saifco Cements	Samman village Khonmoh, **Srinagar**	1.4425 Sq. Kms.
03	M/S Khyber PVT. LTD.	Village Sekinar, Khonmoh **Srinagar**	14.93 ha
04	M/S H K cements	Qutargan zantrag Khrew Tehsil pampore **Pulwama**	4.460 ha
05	M/S Cemtac cements	Salina Satur marg Khrew, **Pulwama**	29.4151 ha
06	M/S TCI cements	Gunsnar bajarnar Wuyan **Pulwama**	44.00 ha
07	M/S TCI MAX	Bathan Khrew **Pulwama**	4.92 ha
08	M/S Valley cement industry	Kutmarg Khrew pampore **Pulwama**	3.82 ha
09	M/S Arco Cements	Zantrag pampore **Srinagar**	65.9 ha

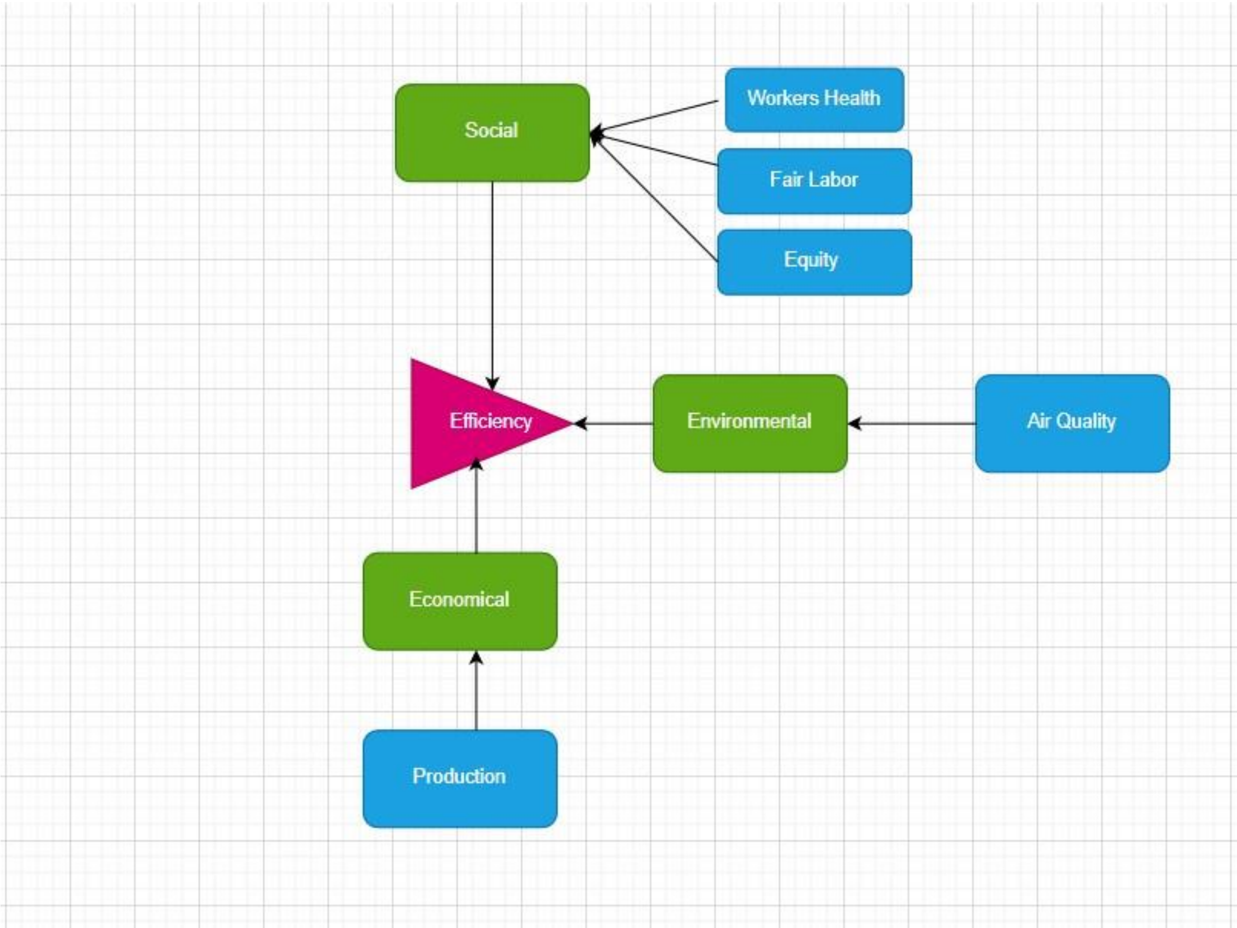
Source: Department of geology and mining, J&K.

Figure 1.1: Satellite view of cement plants



Source: Google Earth

Figure 1.2: Conceptual Framework of the Study



Source: Author’s work based on Literature Review

1.6 Theoretical framework of the study:

This research evaluates the cement business in Kashmir by utilising multiple theoretical frameworks that incorporate social welfare, environmental sustainability, industrial efficiency, and policy compliance. Economic efficiency, environmental effect, social efficiency, and the role of government policies comprise the framework's four main elements. Specific theories and concepts that inform the study's analysis serve as the foundation for each of these dimensions.

1.6.1: Economic Efficiency:

The fundamental components of the study's economic framework are efficiency analysis and production theory. The MPI and DEA are specifically used in the study to assess the cement plants' production efficiency. **Frontier efficiency theory (**Nobel Laureate Harry Markowitz in 1952), which compares decision-making units (cement plants) to the highest-performing units in terms of how well they transform inputs into outputs, is the basis of these tools. This study is further supported by the notion of **Economies of Scale (Adam Smith, 1776)**, which postulates that businesses operating at bigger scales may experience cost benefits that result in increased production.

1.6.2: Environmental Impact:

Environmental impact assessments (EIAs, 1976-1977) and **Sustainability Theory** (UNBC, 1987) serve as the foundation for the framework's environmental component. Given that the cement industry contributes significantly to air pollution, particularly particulate matter like PM10, it is examined in light of the externalities theory and the polluter pays principle, which contend that businesses that harm the environment ought to foot the bill for mitigating its effects.

Ecological Modernisation Theory (Joseph Huber, 1980's): This theory contends that technology advancements and governmental actions can reconcile environmental sustainability with industrial development. The study evaluates the ways in which cleaner technology might be used by cement factories in Kashmir to lessen their environmental impact while sustaining industrial expansion.

The Environmental Kuznets Curve (Simon Kuznets, 1955) is a theory that suggests that as societies demand higher environmental standards, pollution will eventually decline after first rising with economic expansion to a particular threshold of income per capita. By looking at how long-term environmental damage could be mitigated by technological advancements and regulatory measures, the study indirectly connects to this hypothesis.

1.6.3: Social Efficiency:

The framework's social dimension incorporates concepts from human capital, equality, and labour welfare theories.

- **Labor Welfare Theories:** In industrial settings, these theories emphasise the significance of worker health and safety, as well as fair remuneration and equitable labour practices. The study assesses the relative contributions of these aspects to the overall social efficiency of the cement sector.

- **Equity Theory (Adams, 1963):** This idea is applied to evaluate labour practices, promotion policies, and pay equity. Workplace justice as perceived by employees can have a big impact on motivation, productivity, and job satisfaction.
- **Human Capital Theory (Becker, 1964):** The study also makes use of this hypothesis, which holds that spending on employees' health, safety, and skill development increases their productivity and benefits the company as a whole. An assessment of social efficiency must take into account the connection between industrial success and worker welfare.

1.6.4: Role of Government Policies:

Institutional theory and theories of policy execution serve as the foundation for the framework's regulatory and policy component.

- **Institutional Theory (Meyer & Rowan, 1970s):** According to this idea, organisations function inside a system of norms, rules, and laws that influence how they behave and perform. The study looks at how laws such the National Clean Air Programme (NCAP), the Minimum Wage Policy (MWP), and OHS standards affect the sustainability and compliance of the cement industry.
- **Policy Implementation Theory (Leonid Hurwicz):** The success of policy implementation is influenced by a number of elements, including organisational culture, stakeholder participation, and leadership. This theory highlights the difficulties in putting policies into practice. The study investigates the obstacles and variables that affect the compliance of cement companies operating in Kashmir with these policies.

1.7 Significance and Scope of the study:

By aiding in infrastructure and building projects, the cement sector is essential to Kashmir's economic growth. But it has a lot of obstacles to overcome, especially when it comes to economic efficiency. There are numerous cement facilities in the area that use antiquated technology and poor resource management, which lowers their competitiveness and reduces production. The industry's long-term survival depends on enhancing operational performance and embracing innovation; thus, it is imperative to find and fix these inefficiencies. In a continuously changing industrial scene, cement companies in Kashmir may find it difficult to remain profitable and competitive if they do not have a good understanding of the variables behind changes in productivity.

Furthermore, the effect of the cement industry on the environment are becoming a bigger worry, especially in places like Khanmoh and Khrew where particulate matter emissions have caused the quality of the air to decline. This pollution has a long-term effect on public health and puts the health of the communities it surrounds at considerable danger. The increasing worldwide emphasis on sustainability necessitates assessing the impact of industrial operations on local surroundings and devising policies that achieve equilibrium between ecological responsibility and economic development Comprehending the ecological ramifications of cement manufacturing is imperative in formulating area-specific approaches to alleviate pollution and foster sustainability in Kashmir.

Furthermore, despite the industry's high labour force participation, social welfare concerns such worker health and safety, ethical labour practices, and job satisfaction are still not adequately addressed. Enhancing occupational health and making sure that employees receive fair compensation for the risks they assume are crucial. An investigation into the social efficiency of the sector will clarify issues surrounding working conditions, point out areas in need of development, and contribute to the creation of a more just and secure workplace. Resolving these problems will help the industry remain sustainable in the long run by improving morale and production in addition to helping the workers.

Ultimately, the cement business is governed by laws and policies such the National Clean Air Programme, the Minimum Wage Policy, and Occupational Health and Safety rules. But nothing is known about how well these policies are being implemented or working in the Kashmiri setting. It is imperative to evaluate the enforcement of these regulations and their influence on industry compliance to guarantee that the industry functions sustainably and compliantly with national standards. This research will close the knowledge gap regarding how these policies affect the performance of the industry and direct future policy initiatives.

Due to its contribution to the creation of jobs and infrastructure, the cement industry in Kashmir is extremely important to the local economy. It does, however, function in a setting with distinct socio political, environmental, and regulatory difficulties that set it apart from other areas.

Despite its importance, academic studies on the efficiency and sustainability of this industry in Kashmir are conspicuously lacking. Previous research had a tendency to generalise industrial performance throughout India, ignoring the unique circumstances of the industrial landscape in Kashmir. Furthermore, the environmental issues associated with cement production are exacerbated by the region's delicate ecology, namely in relation to particulate matter emissions and declining air quality. Particularly in regions like Kashmir that are less industrialised or prone to conflict, social sustainability factors like fairness, fair labour standards, and worker health and safety are frequently overlooked in industrial assessments. Furthermore, government policies and regulatory frameworks have a significant impact on the region's sectors, which makes it a perfect case study for examining the relationship between performance, sustainability, and compliance. This study intends to close these knowledge gaps by concentrating on the cement sector in Kashmir and providing region-specific insights that can guide practice and policy in support of sustainable industrial growth.

Significant regulatory gaps still exist in the context of Kashmir's cement sector, despite the existence of national labour and environmental standards. One of the main issues is the lax enforcement of environmental laws; cement factories frequently function without proper dust control equipment or routine air quality checks, which results in uncontrolled particulate matter emissions. Furthermore, the area lacks a customised industrial policy that takes into consideration its particular geopolitical and infrastructure difficulties, like limited transit options and frequent interruptions brought on by political upheaval. Another neglected issue is the welfare of the workforce, as seen by the poor application of occupational health and safety regulations, restricted access to health insurance, and insufficient safety training, especially for contract workers. Fair labour practices and equity issues, such as salary inequality and employment insecurity, are pervasive but often ignored by current regulatory frameworks.

Furthermore, because regulatory agencies lack adequate funding and compliance reporting is opaque, monitoring and accountability systems continue to be ineffectual. Bureaucratic inefficiencies and a gap between policy design and the realities on the ground often prevent national labour and sustainability programs from having a local impact. Last but not least, there is no comprehensive strategy that tackles sustainability's environmental, social, and economic facets all at once, leading to disjointed and ineffectual policy results. These disparities show how urgently the cement industry in Kashmir needs broad, context-specific governmental reforms.

1.8 Study Structure:

There are eight chapters in the current study. An overview of the cement industry is given in Chapter I. An exhaustive examination of the literature on the cement industry's aspects, including social efficiency (equity, fair labor practices, and worker health), economic efficiency (production), and environmental efficiency (air quality), is presented in Chapter II. The research instrumentation, statistical tools for data analysis, and limitations are highlighted in Chapter III. The economic efficiency of the cement industry is covered in Chapter IV, along with the productivity efficiency of cement plants. The environmental effects of the cement industry, including the degradation of air quality, will be examined in chapter V. The social effects of the cement industry, such as worker health, ethical labor practices, and equity among cement plant employees, will be assessed in chapter VI. Chapter VII evaluates the government policies for the sustainability of the cement industry. In Chapter VIII, the summary, conclusion, and policy implications are covered.

Chapter 2

Literature Review

The chapter provides a summary of earlier research on the cement industry and its associated aspects. The review follows thematic groups that align with the study's variables and sub-variables. These factors include social, environmental, and economic efficacy, as well as sustainable government initiatives. We will go into excellent detail about each of these variables and their sub-variables, referencing previous studies and theoretical frameworks. This particular chapter conducts a thorough national and international literature review to highlight the numerous concerns related to the current study. The literature identifies knowledge gaps in the field and offers academic and research perspectives from a variety of angles. We review the literature on various topics such as economic efficiency (production efficiency), environmental efficiency (air quality), and social efficiency (worker's health, fair labor, equity) in the cement industry.

2.1 Economic efficiency

Two essential components make up a firm's economic efficiency, according to Farrell's 1957 research. The first is technical efficiency, which gauges how well a business produces goods using its resources. The second is allocative efficiency, which shows how well the company manages to balance input costs and marginal revenue products in order to maximize profits. When combined, these elements offer a complete picture of an organisation's financial performance, including both production capability and financial sense (Aigner et al., 2007). It makes sense to believe that different approaches to applying input could result in different output outcomes. In other words, given a comparable set of inputs and technology, a company that employs the best practice method produces the highest possible output, which is superior to a company that does not do the same, according to Meeusen and Van den Broeck (1977). In their

1980 paper, Schmidt and Lovell explored how to determine whether there exists substantial link between technical and allocative efficiencies, as well as how to take this correlation into account when generating reliable frontier estimates. Nevertheless, they employed average technical efficiency metrics, the cost-minimisation hypothesis, and Cobb-Douglas technology.

Bates and Rapper (2001) assert that a business cannot achieve long-term growth if it exhausts its human or natural resources; it must prioritize economic efficiency. In order to sustain economic growth, businesses cannot harm the environment or their communities any longer, as this would cause the environment in which they function to become unstable. The study by Ricardi et al. (2012) called "Efficiency analysis of world cement industries" found that capital allocations in emerging technologies, the use of different fuels and feedstocks, and the existence or nonexistence of harmful substances (CO_2) in the processes of making cement and clinker all have an effect on how efficient the industries are. According to Ricardi et al. (2012), countries that invest in alternative fuels and raw materials experience greater success when both voluntary and statutory emission regulations are in place. They accomplish this by utilizing the DDF and traditional DEA models to pinpoint the sources of efficiency and inefficiency. Oggioni et al. (2011) provided a cross-national evaluation of the eco-efficiency of the global cement industry. Utilising DEA methodology, this study evaluates the impact of environmental regulations on the effectiveness of the cement industry through the examination of a collaborative production framework that includes both desired and unwanted products. The concept of efficiency is critical in determining how regulations will affect society.

In the output version, efficiency can be demarcated as a company's capacity to generate the highest possible level of outputs given a given set of inputs. S Bandyopadhyay (2009). The input mix that the company uses can change as a result of changes in technology, input prices, or other factors, which can impact efficiency. Charnes et al. (1979). Productive or technical efficiency (TE) is the firm's capacity to produce as much as possible without accounting for the impact of input prices; on the other hand, price or allocative efficiency is the measurement of efficiency that takes the effect of input prices into account. Both of the efficiency components affect a firm's overall performance. Watanabe et al. (2007). When the rate of factor substitution does not match the ratio of factor costs, the firm loses efficiency and fails to minimize the social cost at the output level it selects. Averch and Johnson (1962). People consider estimating productivity or efficiency as a comprehensive performance evaluation indicator. Empirical studies measuring a company's productivity and efficiency are growing in number and popularity among governments, policymakers, management organisations, and other important stakeholders. Sall & Parkar (2000). The debate over the proper estimator of productivity and efficiency remains unresolved, despite the widespread use of measurement practices resulting from substantial methodological breakthroughs in recent years Chirwa (2004), Cullinane & Wang (2005), and Fare et al. (1985) have all contributed to this debate.

2.1.1: Production efficiency of Cement Industry:

Achieving sustainable growth and competitiveness requires any organisation to prioritise production efficiency. Producing the greatest amount of goods and services possible given the resources at hand is known as productive efficiency. Afriat, S. N. (1972). The key to productive efficiency is making the most use of resources while generating the least amount of waste (Coelli et al., 2005). This might involve, within a single business producing for specific customers, creating the greatest quantity of goods or services possible based on microeconomic resources. Aigner and Porier (1976). Thinking about the total resources available within an economy and how to produce across multiple industries as efficiently as possible (Battesse et al., 1995) can also be done on a macroeconomic scale. The literature of Hollingsworth & Bruce (2008) identifies numerous factors affecting production efficiency in diverse industries and organisational contexts. These factors can be classified into two groups: internal and external determinants. Internal factors include organizational culture, workforce training, managerial abilities, and technological adoption. Berger et al. (1997). Infrastructure, macroeconomic stability, market conditions, and regulations all fall under the category of external factors. Kumbhakar et al. (1982). Furthermore, as production efficiency increases over time, elements like learning effects, economies of scale, and scope become increasingly important "Afonso et al. (2016); Klassen et al. (2001); Ozkan et al. (2017)".

The construction sector, characterised by its labour intensity, relies predominantly on human effort and performance for productivity (Stoekel and Quirke, 1992). This effect not only validates concerns about labour productivity, but it also suggests that labour power is the only productive resource. Abid & Terrell (1998) conducted a study on the production efficiency of small firms, according to the authors. By increasing overall technical efficiency, firms can increase output by 6 to 29%. This suggests that these small manufacturing businesses have room to improve their efficiency. Karl et al. (2004) found that Austrian insurers' production efficiency increased as a result of deregulation, with gains observed in both life/health and non-life businesses. Kesava's (2020) study reveals that the Indian cement industry's capacity utilisation falls below the ideal threshold of 80%, leading to issues such as high production costs, meagre profits, and operational difficulties. Absence of physical infrastructure, including power, coal, and railway wagons is one factor causing underutilization. Seema Sharma (2008) carried out a study that analysed the TE and SE performance of cement firms. findings indicate that 50% of businesses are operating at their maximum size and efficiency, 25% are using their capacities too much, and the remaining 25% are not using them enough. We advise inefficient firms to adjust their input. Overall, with average scores of 0.96 and 0.97, correspondingly, the industry shows high technical and scale efficiency.

Researchers like Ahluwalia (1991), Mongia & Sathaye (1998), Schumacher & Sathaye (1999), Kathuria (2002), Sharma & Banerjee (2007), CSO (1981), and Golder (1986) have used growth accounting, econometrics, stochastic frontier analysis, and DEA to look into the productivity-related parts of the Indian cement industry. Capital, labor, material, and energy are the four factors of production for which Sharma (2007) constructed partial indices, as well as the total productivity index using the Divisia Tornquist index. The findings demonstrated that, between 1989 and 2005, there was a notable drop in the overall productivity index for the cement industry in India. The partial index results further corroborated this conclusion about the inefficient use of inputs in this industry. Pradhan and Barik (1999) demonstrated scale diseconomies from 1963 to 1993, however Jha et al. (2001) indicated substantial economies of scale from 1960 to 1983. Using firm-level data and the stochastic production frontier approach, Kathura (2002) examined the productivity performance of Indian industries. The cement industry saw 0.0076 percent annual productivity growth in the post-1991 reform period, which ran from 1991 to 1996. Banerjee (2007) made an additional attempt to investigate how environmental guidelines affect the technical efficiency of the cement industry in India. The study, which used DEA, discovered that efficiency was higher in the first few years of regulation (1999–2000) than it was in the following years (2003–2004). This study doesn't discuss industry firms' efficiency in comparison.

This study fills a big hole in the literature on India's cement industry. Until now, no one has conducted a non-parametric analysis of the comparative production efficiency of cement companies in India. In order to address this gap, our paper uses the VRS/DEA model to assess the SE and TE of Indian cement companies. This study adds significantly to our current knowledge of productivity and efficacy in the Indian cement industry.

2.1.2: Data Envelopment Analysis

Over the past few decades, various sectors such as “banking, healthcare, education, the automotive industry”, the energy sector, and research institutions have employed the DEA for productivity and efficiency assessments. Kamanhou et al. (2024) did a comprehensive evaluation of research pertaining to the DEA. Tone et al. (2020) provide a summary of the methodological improvements in DEA. The forthcoming debate will examine the efficacy and productivity analysis of the cement sector as presented in prior research.
To look into the productivity-related aspects of the cement industry, different researchers have used methods like growth accounting, econometrics, the CUSUM technique, DEA, and SFA. These researchers include Riccardi et al. (2012), Sadjadi & Atefeh (2010), Sharma (2007), Banerjee (2007), Valizadeh et al. (2020), Chari et al. (2009), Ghulam & Jaffary (2015), Long et al. (2015), Bandyopadhyay (2009), Wheelock & Wilson (2003), Jha et al. (2001), and Sharma (2008). Riccardi et al. (2012) assessed global cement production efficiency and scrutinised the impact of CO_2 emissions laws on this efficiency. This study utilises DEA to discover solutions for reducing CO_2 emissions while simultaneously preserving or enhancing production efficiency by accounting for unwanted outcomes. The study's results demonstrate that CO_2 emissions substantially affect the efficiency levels of the cement industry. The research revealed that incorporating CO_2 emissions into the efficiency models produced statistically significant variations in efficiency ratings, underscoring the necessity of factoring in environmental considerations in performance assessments. The analysis identified Brazil and China as the two most efficient countries in the cement industry. Sadjadi and Atefeh (2010) calculated productivity estimates for the cement sector using the Kendrick Index from 2000 to 2010. He

reported a growth rate of -1.06 percent over this period. In 2007, Sharma, S. developed component indices for the four production factors—materials, labor, capital, and energy—along with an overall productivity index utilizing the Divisia Tornquist index. The comprehensive productivity index for the Indian cement industry declined sharply from 1989 to 2005, as indicated by the study's results.

Banerjee (2007) attempted an investigation into how environmental regulations distress the TE of the Indian "cement industry". According to the study, efficiency was higher in the first few years of parameter (1999–2000) than it was in the latter years (2003–2004) while using DEA. However, the study does not offer an analysis of the efficiency performances of individual companies within the industry. Valizadeh et al. (2020) evaluated the relative efficiency of the cement industry using DEA, analysing financial data from 2012 to 2016. The study's findings suggest that the inherent and acquired abilities of managers significantly influence the efficiency or inefficiency of companies in the Iranian cement industry. Additionally, the study emphasised that the management ability index should not be considered in isolation from relative efficiency. The study also acknowledged the potential impact of external factors like inflation, price index, and interest rates on the relative efficiency of the companies, although the research did not address these in detail Chari et, al, 2009.

The study used DEA to examine the technical and scale efficiency of 32 cement makers in India. We conducted this analysis over a three-year period (2006–2008), providing a longitudinal view of these enterprises' efficiency within the Indian cement industry. The study investigated 15 companies that are efficient; they have a DEA score equal to 1, and 9 companies are inefficient. The reason for inefficiency is scale inefficiency, and the rest of the companies were in the category of declining and improving efficiency. Ghulam & Jaffary (2015) estimated the impact of deregulation and privatization on the efficacy of cement firms in Pakistan. Researchers applied the DEA model and found that technological growth led to productivity improvements in the Pakistani cement industry. Long et al. (2015) (1986) assessed 0.50 annual TFPG (TFP growth) for the period 2000–2010. Another study by Bandyopadhyay, S., 2009, based on the Tanslog index, found -0.5 annual TFPG for the period 1996-2008. Consequently, the outcomes of growth accounting studies conducted by various academics are widely disputed. Variations in the index selection process can explain this. Wheelock & Wilson, 2003, aimed to analyse the industry's performance, efficiency, and productivity over the period 1984-2002. By employing nonparametric methods, the study found that while there were significant investments in technology and a more competitive environment, the evidence for improvements in productivity and efficiency was mixed. Some showed improvements in profit productivity, particularly early adopters of new technologies, but overall average cost productivity declined during the period studied. They computed a translog cost function to examine factor substitution, scale economies, and technological revolutions in the cement industry in India. According to their study, the cement sector experienced significant economies of scale throughout the 1960–1983 study period, as evidenced by the elasticity of cost about output of 0.139. Additionally, they discovered that there were plenty of opportunities for substitution across all production parameters. Throughout the study, technological advancements have been capital-saving and skewed toward the use of labor, energy, and materials.

Sharma (2008) conducts a non-parametric examination of production efficiency in Indian cement businesses. It specifically seeks to assess these companies' relative TE and SE for the years 2005-2006. The study, utilising DEA, determined that the industry exhibits strong performance in both scale and technical efficiency, with average scores of 0.96 and 0.97, respectively. The results indicate that 50% of the 20 enterprises demonstrated technical efficiency and optimal plant size. Nonetheless, 25% of the enterprises showed diminishing returns to scale, reflecting overutilization of their production capacities, while another 25% displayed increasing returns to scale, indicating underutilisation of their facilities. Long et al. (2015) examined total factor productivity and eco-efficiency in China's cement manufacturing sector from 2005 to 2010, uncovering inconsistencies between total factor productivity and eco-efficiency in this industry. Malmquist and Malmquist-Luenberger are differentiated from one another. The Malmquist index and the Malmquist-Luenberger index demonstrate a U-shaped correlation with the industrial value per labour of cement manufacturers, consistent with the environmental Kuznets curve theory.

After a wide-ranging review of the literature, we found that there has been a discernible absence of contemporary scholarly research on the economic efficiency of the cement industry. Prior to 2015, the majority of research on economic efficiency was published in various studies. Even if these older studies offer insightful analyses of several facets of the industry's performance, they are becoming increasingly out of date, particularly in light of the significant changes the cement industry has seen recently. A more recent study has focused on environmental (Poudyal & Adhikari, 2021; Ighalo & Adeniyi, 2020; Rocha et al., 2022; Ahmad et al., 2021) and energy efficiency. Research by Cantani et al., 2021; Wang et al., 2023; Makthoor & Masooti, 2023; Saho & Kumar, 2022; Zhnag et al., 2022, which focusses on environmental rather than economic efficiency, is particularly noteworthy as it reflects the growing global emphasis on sustainability and resource optimization. Despite the cement industry's perilous role in economic progress and significant GDP contribution in many regions, there has been surprisingly little in-depth research on its economic efficiency over the last ten years. The paucity of research in this area underscores the necessity for more recent studies that explore strategies for maximizing economic efficiency amidst shifting market dynamics, technological advancements, and regulatory requirements, all of which are gradually transforming the competitive landscape in the cement industry. Our study seeks to fill this knowledge gap by offering current information on the cement industry's economic efficiency.

2.2 Environmental Efficiency:

The environment is one of the most important challenges facing socially and economically sustainable development today. Assessing environmental efficiency across various sectors and regions has significant practical implications. This work provides an objective point of reference for improving environmental performance, as well as helping people understand the differences between their environmental performances. The cement industry plays an important role in raising living standards globally by creating direct employment opportunities and other positive cascade effects for related businesses. Despite its popularity and profitability, the cement industry faces numerous sustainability and environmental challenges. So_x, NOx, and particulate matter are the three principal emissions that impact the environment.

Kuang et al. (2009) identify population growth and economic expansion as the primary drivers of emissions. The two process-related variables that are most responsible for environmental pollution are using old kiln shafts and direct calcination “Lei et al., 2011 & Song et al., 2016”. Emissions from cement manufacturing, which include metals or metal dust particles, can significantly damage the surrounding environment and pose health hazards to employees. “W.

Shen et al. ,2016: Wang et al. ,2016" reported that three cement facilities in China had mercury emission factors of 0.044, 0.062, and 0.072 g/t cement, respectively. The principal source of mercury emissions is the kind of fuel, raw materials, and dust collectors used in the production process. Sikkema et al. (2011). Researchers studying the Chinese cement industry have raised concerns on the emissions of other deleterious compounds, including carbon monoxide (CO) and heavy metals. The study was conducted by Wang et al. (2013) and Lei et al. (2011).

After China, the United States, and Russia, India is the fourth-largest emitter of greenhouse gases (Balsara et al., 2019). On a domestic basis, India's cement industry ranks second in terms of CO2 emissions and the country's third-largest energy consumer (WBCSD, 2013). Carbon-intensive fuels such as coal are a significant additional source of CO2 emissions. Coal provides about 73% of the energy needed for production, raising serious concerns about the sustainability of the Indian cement sector Mandal & Mahdeswaran, 2011. Chen et al.'s 2010 study, "Environmental impact of cement production: detail of the different processes and cement plant variability evaluation," identified the four main environmental indicators that the cement industry impacts: global warming, acidification, marine ecotoxicity, and abiotic depletion. Mishra et al. (2022) noted that India, having risen from 337.32 million tonnes in 2019, is the second-largest cement producer globally behind China, with an installed capacity of 537 million tonnes and around 7.1 percent of worldwide production. Common air pollutants from the manufacture of cement include, NOx, Sox and particulate matter. By 2050, using environmentally friendly methods and technologies and transitioning to alternative fuels will reduce emissions by 12% overall. Dawoudian et al. (2021) in their study "Environmental impact assessment of cement industries using the mathematical matrix method" revealed that public health had the least harmful impact, whereas excavation and terrain deformation had the most.

The study also found that the employment of compensating elements lessened the project's detrimental impact on the environment. To reduce the environmental impact of projects using conventional environmental improvement techniques such as erosion control, it is critical to locate facilities properly and create green spaces. Devi et al. (2018) found in their study that the global cement industry is expanding and causing environmental and health problems for people. Cement manufacturing plants cause significant environmental deterioration, particularly in terms of air quality. During the production process, cement manufacturing plants release particle matter and gaseous emissions, both of which significantly contribute to the escalation of air pollution. These industrial by-products harm the atmosphere around them and add to more general environmental worries. The use of appropriate technology and computer modelling will help the industry comply with environmental protection laws, control air pollution, and reduce production waste. It also examines how effective energy use can enhance air quality, as well as the application of computer modelling for particulate matter classification, quantification, and control.

Satajanka & Estokova (2012) conducted a study on “Environmental impacts of cement production" and observed that the building sector is one of the worst polluters of the environment, causing resources, using energy, or producing waste. Additionally, there are significant emissions of acidifying, and greenhouse gases have their roots in the construction sector. Cement factories need to control their emissions of sulphur dioxide, carbon dioxide (CO2), nitrogen oxides (NOx), and dust (SO2). Igalou and Adeniyi (2020) conducted a study titled “A Perspective on Environmental Sustainability in the Cement Industry.” Researchers have disclosed that they have suggested methods such as carbon capture and storage (CCS), material substitution, alternative fuel utilisation, and the adoption of energy-efficient technology to mitigate the adverse environmental impacts of cement manufacturing. Huntzinger & Eatmon (2009) examined that cement production accounts for approximately 5% of global CO2 emissions and generates millions of tonnes of cement kiln dust (CKD), a waste product that endangers respiratory and environmental health. This study utilises LCA to evaluate environmental effects. Exposure to cement facilities poses health dangers to both the community and the workers. Cement manufacturing and transportation unimpededly emit gases and particles into the environment (Raffetti et al., 2019). Particles generated from activities such as excavation, drilling, blasting, extraction, cement manufacturing, fuel manufacture, packaging, road maintenance, and settlement consist of dust and carbon particles Mishra and Siddiqui (2014).

2.2.1: Air quality Impact:

The cement industry is considered the predominantly polluting sector. The production of dangerous gases such as carbon monoxide (CO), sulphur dioxide (SO2), nitrogen oxides (NOx), and dust particles requires a significant amount of energy. One of the key causes of greenhouse gas emanations, including CO2, is the cement industry Ekinci et al., 2020. Right now, it is imperative to protect natural resources without sacrificing rapid growth. Currently, the cement industry's GHG emissions make up about 8% of all national emissions (Uzma et al., 2018). PM, CO, NOx, Sox, and hydrocarbons are air pollutants emitted during production. The processing of raw materials, clinker manufacturing and storage, bulk cement loading, final product packaging, and power generation activities all emit pollutants. "Fore and Mbohwa, 2015; Gupta et al. ,2012; and Hasanbeigi et al. ,2012" have all documented these emissions.

Air pollutants emitted from both fixed and mobile sources in cement manufacturing facilities may adversely affect the environment and human health. Previous studies have demonstrated that communities adjacent to cement factories experience elevated pollution levels. Studies by "Abdul-Wahab, 2006; Bertoldi et al. ,2012; Eom et al. ,2017, Jayadipraja et al., 2017 and Rovira et al., 2011" have all confirmed this. Research has linked the heightened morbidity and premature mortality of people living near cement production facilities to pollutants emitted into the surrounding areas Bertoldi et al., 2012. Various health complications, including "sterility, cancer, respiratory illnesses, pulmonary ailments, and cardiovascular diseases", have been associated with exposure to PM and gaseous fuel combustion products Adeniran et al., 2017.

The negative effects of deteriorating ambient air quality may have a dramatic impact on human health and well-being. Extensive research indicates that air pollution has adverse effects on materials and vegetation, compromises animal and human health, reduces Arya, 1999. Strategies for regulating air quality are essential for mitigating the adverse consequences of air contaminants and mitigating the effects of human-induced emissions Ozkurt (2011). Several procedures, including air-quality monitoring, emission inventory creation, control strategy delineation, and long-term compliance monitoring, are chiefly responsible for their generation Molina & Molina, 2004. Determining the pollution from various sources and looking into how it affects ambient air are crucial for creating effective air-quality management plans Bhanarkar et al., 2005. In addition, the strategies must help cities develop a pattern of sustainable growth and methodically address both the immediate and long-term sources of air pollution Elbir et al., 2010.

The main tasks engaged in air quality evaluation and administration are emission determination, air quality monitoring, and modelling. Ying et al., 2007. Since it's not always possible to continuously monitor pollutants over an extended period of time and space, air quality modelling is a commonly used technique to guess the pollutants in a desired region. “Kumar et al.,1999; Cora and Hung, 2003; Rama Krishna et al., 2005”. Although there are restrictions on the choice and application of these strategies, cement plants can lower their carbon footprint by implementing waste heat recovery, renewable energy substitution, energy efficiency upgrades, and alternative materials. Ishaq & Hashim (2015). Policymakers can make sustainable decisions about managing air quality by using a system dynamics model to evaluate how the cement industry affects air pollution in urban areas. Ekinci et al. (2020). According to Mishra et al.'s (2019) study on "Ambient Air Quality and Indexing with Reference to Suspended Particulate Matter and Gaseous Pollutants Around a Cement Plant in OCL India Limited, Rajgangpur, Odisha, India," the air quality around a cement plant in Odisha, India, meets the standards because of high-tech devices that trap air. The air quality is only moderately polluted (PM10) and good (SO2 and NOx). China's cement production has largely contained harmful air pollutants, but future synergistic reductions of CO2 and HAP emissions will depend on the development of ultra-low emission and low-carbon technologies. Guo et al. (2022). According to Zhang et al. (2015), improving energy efficiency in China's cement sector can lower emissions of CO2 and other air pollutants.

In industrial regions, the adverse effects of cement dust on specific plants make air pollution a significant threat to plant life “Gupta and Mishra,1994 and Lameed and Ayodele, 2008”, in their study on the environmental effects of cement production on flora &fauna near the UNICEM, reported that most of the lower plants at the factory site exhibited dehydration due to insufficient rainfall, but they detected no disease symptoms. Adak et al. (2007) assert that emissions from cement factories and the particulate matter they discharge into the atmosphere degrade air quality and contribute substantially to environmental degradation. Tiwari et al. (2011) assessed air pollutants such as respirable suspended particulate matter (RSPM), suspended particulate matter (SPM), sulphur dioxide (SO2), and nitrogen oxides (NOx) at Naubasta hamlet, adjacent to the J.P. Cement Plant in Rewa (M.P.). The study revealed that while the Central Pollution Control Board (CPCB) in New Delhi established standards for gaseous pollutants (SO2, NOx), the average concentrations of SPM and RSPM in the village's ambient air surpass the allowed levels. Pollutant concentrations rise in winter, moderate in summer, and decrease during the wet season, according to research. Adding cement kiln dust to the soil at levels between 1.0 and 48 g/m2/day can change the alkalinity of the soil, which can help some plants but hurt others (Lerman and Darley, 1975).

Furthermore, an analysis of the elemental composition of soils near two cement manufacturers in Nigeria, based on thirty samples, indicated the existence of these components. The soils of the cement factory's premises exhibited elevated concentrations of Ca, P, S, Cr, Ni, Cu, and Zn. The amounts of Si and Ti showed an inverse proportionality to calcium, a cement marker element, while the soils showed a positive correlation with Mg, S, Fe, Ni, and Cu. Asubiojo et al., 1991 concluded that cement-related soil contamination diminishes markedly with increased depth from the surface and distance from the factories. Kumbhakar (2002) exhibited notable soil qualities in the vicinity of India's cement plants, particularly in the Gotan industrial area. He concluded that the emission of particulate matter by cement manufacturers may cause variations in parameters such as pH, conductivity, salt concentration, osmotic pressure, and salinity in the vicinity of these industries.

Al-Khashman and Shawabkeh, 2006 identified elevated metal attentions in surface and subsurface soils next to the cement mill compared to urban soils. Despite the detrimental impact of a cement factory on local soil quality, the commendable environmental measures of cement businesses render the soil quality as negligible Siddiqui et al., 2010. “Kubikovd, 1981 &Kabir and Madugu, 2010” investigated the effects of the cement industry on Nigerian air quality and the mitigating techniques used. They proposed various economic techniques, including the use of affordable, readily accessible pozzolana material for blended cement manufacturing, which improves energy efficiency and reduces carbon dioxide emissions in clinker production. They also advised the installation of innovative high-pressure grinding rolls to optimise energy efficiency relative to conventional ball mills. Cement manufacturing plants release hazardous compounds such as “fluoride, magnesium, lead, zinc, copper, beryllium, sulphuric acid, and hydrochloric acid”, as evidenced by Andrej, 1987. Shah et al., 1989 assert that pollution from cement dust is an environmental element that is significantly deteriorating ecological quality.

Baroutian et al., 2006 found where PM10 came from in the Kerman atmosphere and looked at how it spread out, as well as changes in the mass attention and size circulation of PM10. This study primarily examined the Kerman Cement Plant's effect on the local ecosystem. Abdul-Wahab, 2006 examined the effects of fugitive particle emissions from a cement manufacturing facility affecting a proximate residential area. The study's results exhibited a strong correlation between the predicted and measured 24-hour average dust concentrations. Ziadat et al., 2006 looked at the chemical and mineral makeup of dry testimony near a cement factory in Jordan. They discovered that, except for Mo, the concentrations on the rooftops of Fuhais homes were higher than those at a reference site farther away.

Researchers assessed the levels of potentially dangerous constituents in the airborne cement dust at a cement mill in Sagamu, Nigeria. Subsequently, they compared these concentrations with the safety regulations of the United States. Gbadebo and Bankole (2007) determined that the components could provide significant health risks to neighbouring residents, animals, plants, and workers. Burange and Shruti, 2008 investigated the growth and efficacy of the cement sector in India. Boudaghpour and Jadidi (2009) investigated strategies for mitigating and eradicating pollution, as well as the effects of emissions from cement production companies in Tehran. In 2009, Al Smadi et al. forecasted air pollutants (dust, SO2, NOx, and carbon monoxide (CO)) from a proposed cement facility located in the Wadi Alabyad area, approximately 100 kilometres south of Amman, Jordan. Mandal (2010) used Data Envelopment Analysis (DEA) to assess the energy utilization efficiency of the Indian cement sector at the state level from 2000-01 to 2004-05. Chen et al. (2010) employed life cycle impact assessment (LCIA) to evaluate the environmental impact of cement manufacturing and its discrepancies among various cement facilities .

Mandal and Madheswaran (2010) evaluated the environmental performance of the cement sector in India. They assessed both the targeted products and the undesirable by products using the Directional Distance Function and Data Envelopment Analysis methodologies. One context views carbon dioxide as an input, while another views it as an unwanted output, and the concept of environmental efficiency captures this difference. In 2010, Yatkin and Bayram measured the amount of bulk particulate matter (PM) and total suspended particle (TSP) mass concentrations near a cement plant in an area with a lot of different impacts to see how the plant affected the air quality in Izmir, Turkey. Cement conglomerates must adjust their business strategies to remain competitive in the Indian construction materials market, as shown by Shankar et al.'s 2010 study on the historical, current, and future developments in India's cement sector. Santacatalina et al. evaluated the impact of fugitive emissions on the composition and levels of ambient particulate matter (PM) in 2010. The study showed that human-made fugitive emissions have a big effect on the air quality in the L'Alacantí region in the southeast of Spain, especially when it comes to metal concentrations and particulate matter less than 10 microns (PM2.5). The researchers found that the annual mean PM10 levels in the study region for 2006 and 2007 were 6–9 μg/m3 over the standard concentration range for urban areas in Spain, which is 2–7 μg/m3 for PM2.5.

In 2011, Oggioni et al. conducted a cross-national assessment of the global cement sector's eco-efficiency levels. The study employs DEA to examine the impact of environmental legislation on the efficiency of the cement industry, considering a combined production framework that encompasses both desirable and undesirable outcomes. Rovira et al. (2011) did analogous experiments, evaluating the environmental impacts of a cement mill situated near a heavily populated region (Montcada i Reixac, Catalonia, Spain). Ashrafizadeh et al. (2012) investigated the effect of temperature gradient distribution on the exergetic and environmental functions of the cement production process utilizing a secondary burner. Ibrahim et al. (2012) utilised computer simulation to quantify gas and particulate matter emissions from two Portland cement facilities near Khoms city in northwest Libya. The study revealed that the emissions of SO2, NOx, and particulate matter exceed specific international regulatory thresholds. The Maihar cement mill releases sulphur dioxide (SO2), nitrogen oxides (NOx), and suspended particulate matter (SPM). Rai et al. (2013) investigated these air contaminants and Maihar city's air quality. Primary pollutants such as SO2 and NOx exhibited concentrations within the established regulatory limits; however, SPM exceeded the standard value prescribed by the CPCB, New Delhi, for residential and rural applications. The proliferation of cement manufacturers has caused a decline in global human health and environmental destruction. Gilette (1984) posits that air pollution is a societal disease predominantly stemming from human activity, adversely affecting public health and welfare. Studies have shown that exposure to cement dust adversely affects respiratory health, as indicated by a higher prevalence of respiratory problems (Al-

Neaimi et al., 2001). Adak et al. (2007) found that respiratory ailments, gastrointestinal illnesses, and other associated conditions significantly affect individuals living in cement dust areas .

Tiwari et al. (2011) investigated the prevalence of diseases related to air pollution among 200 families in Naubasta village. The study's findings showed that residents living close to cement factories had a higher incidence of respiratory illnesses. According to epidemiological studies conducted in two small Italian municipalities by Bertoldi et al. (2012), there is a link between exposure to air pollution and a number of harmful health effects caused by emissions from cement plants. They discovered a particularly strong correlation, especially for children, between hospital admission risk for cardiovascular or respiratory diseases and exposure to emissions from cement plants. Sana et al. (2013) looked into the health hazards related to the labor force employed in Kashmir's cement factories. Haq et al. (1997) performed a cost-benefit analysis of pollution control apparatus implemented to mitigate dust emissions in the Indian cement sector. Bapat (2001) investigated the use of electrostatic precipitators (ESP) for gas cleaning in the cement industry, taking Indian conditions into account. In their 1997 study, Saralabai and Vivekanandan examined the impact of extra-cellular polysaccharide (ESP) dust on crop productivity and pollen fertility in Tamil Nadu. They discovered that the dust had a substantial negative effect on pollen fertility in noncleistogamous (open-pollinated) flowers. Every development project, according to Agrawal (2002), will inevitably alter the human environment to some degree. The rapid changes brought about by housing and industrial projects are frequently breath-taking in the natural world. Particulate matter concentrations were higher in the industrial area of Gotan, Rajasthan, where Trivedi (2006) conducted an environmental impact assessment (EIA).

Ranade (2007) used remote sensing techniques to examine the environmental impact assessment of land use planning adjacent to the leased limestone mine in Rajasthan's Chittorgarh region. Dutta and Mahatha (2003) emphasised the core concepts of cumulative impacts, the trajectories of cumulative environmental alterations, and the effective framework and methodologies for addressing changes in the environmental impact assessment process. According to an environmental statement report for J.K. White Cement Works in Gotan, environmental impact assessments conducted by Dubey from 1998 to 2001 revealed a decline in the quality of trees, soil, and water in the area. Panigrahi and Amirapu (2012) observed the opportunity to enhance the EIA process by leveraging the current circumstances .

Mathur et al. (2003) performed a statistical investigation of the carrying capacity of the cement and lime industries in the Vindhyan Region of Madhya Pradesh (MP). The researchers associated the Air Quality Index (AQI) with ambient air quality (AAQ) and concluded that the AQI is an effective measure for modelling, monitoring, and evaluating ambient air quality. Mohebbi and Baroutian (2007) performed a comprehensive mathematical investigation to determine the particle dispersion pattern originating from the Kerman Cement Plant in Kerman, Iran. In 2008, Lothongkum et al. used two Gaussian-based models, the American Meteorological Society-Environmental Protection Agency Regulatory Model (AERMOD) and CALPUFF, to figure out how particulate matter (PM) spreads in the air around large cement plants about 100 km northeast of Bangkok, Thailand .

Zerrouqi et al. (2008) projected the effects of cement dust on soil utilising principal component analysis and a geographical information system (GIS). Dutta and Mukherjee (2010) presented a projection scenario for 2001–2031, derived from the MARKAL Modelling exercise for India, which might potentially align with reductions in energy consumption in major industries such as cement, steel, and aluminium under various conditions. In the Environmental Impact Assessment (EIA), Seangkiatiyuth et al. (2011) employed the AERMOD model to assess nitrogen dioxide (NO2) emissions from a cement complex. Abu-Allaban and Abu-Qudais (2011) estimated the air pollutants (dust, SO2, NOx, and CO) emitted by a modern cement mill located in the Jordan Badia area of southeast Amman. The modeling was performed using AERMOD .

Cement emissions cause cardiovascular and respiratory morbidity and mortality (Leach-Kemon 2013; Cackette et al. 2011). Particularly, studies (Zeleke et al., 2010; Aydin et al., 2010) suggest that PM may contribute to the development of itchy eyes, cardiovascular disorders, chest discomfort, chronic bronchitis, asthma attacks, and a number of malignancies. Inhalable dust emissions from cement production plants, typically significantly higher than those near construction sites, exacerbate the health of the population most at risk (Tiwari et al., 2010). This is especially true during cleaning tasks. PM emissions cause an average of 3.2 million premature deaths per year. Research has shown that PM emissions from cement factories put surrounding communities at risk within a radius of 1.2 to 1.5 km (Tiwari et al. 2010; Marcon et al. 2014; Syed et al. 2013). Lack of preventive measures, such as raising awareness and providing personal protective equipment and tools, could result in a high-risk level (FDRE CSA 2007–2008) .

Consequently, the most susceptible groups are schoolchildren, residents in the surrounding community, and employees of cement factories. Just 7% of the workers in the cement industry in a related study by Zeyede (2011), only 7% of cement industry workers used respiratory protective equipment. The follow-up study found that cleaners' cumulative exposure to GM dust was 432 mg/m3. Despite the high levels of exposure among production workers (Gizaw et al., 2016), the Dejen cement factory in west-central Ethiopia reported a 62.9% prevalence of chronic respiratory symptoms among its workers. The symptoms most commonly experienced by the workers were chronic cough (24.5%), chronic wheezing (36.1%), chronic phlegm (24.5%), chronic shortness of breath (386.6%), and chest pain (20.0%). The following factors have been linked to persistent respiratory symptoms: smoking, chronic respiratory diseases, sex, age, education level, cement mill, burner, and clinker, work experience, and occupational safety training. Although the concentrations were significantly lower (GM = 8.2 mg/m3), 48% of them were still higher than 10 mg/m3. Standard precautionary risk prevention and controlling mechanisms are absent from Ethiopia's industrial expansion strategy (Oluwasinaayomi et al. 2018; Etyemezian et al. 2005) .

Consequently, industry contributes to higher levels of air pollution in urban areas. Emissions from the cement industry deteriorate the air quality in areas surrounding the factory within a radius of 3.4 km (World Bank 2004). Theoretically, four processes—advection, difusion, ground deposition, and chemical transformation—determine the concentration of contaminants in the environment (Boubel et al. 1994; Carruthers et al. 1994; Wijeratne et al. 2006). The aforementioned processes serve as the foundation for various pollution models, including the dispersion model, particle model, odour model, photochemical model, and remote sensing dispersion model. Nkhama et al. (2017) and Peters (2009) state that there hasn't been a thorough investigation on the state of the communities' health in relation to cement emissions near cement factories up until this point. Most research projects lack an integrated method for determining the emission levels from cement factories, both inside and outside of the factories, as well as their effects on human health, which is necessary for potential mitigation measures .

2.3 Social Efficiency:

Social efficiency refers to the distribution of resources and goods in a way that maximizes the welfare of the entire society. We accomplish social efficiency when we use resources to produce the greatest possible benefit for society as a whole. In addition to social welfare considerations like equity and fairness in resource distribution and opportunity access, this concept also takes into account economic factors. Georgia et al. (2017). Fundamentally, social efficiency aims to strike a balance between allocating resources in a way that maximises the well-being of both individuals and communities. Bibi et al. (2018). In contrast, social sustainability pertains to the enduring welfare of a community and is concerned with preserving and improving social structures, cultural authenticity, and communal unity over an extended period of time (WCED, 1987). Social sustainability refers to a society's ability to meet the needs of its members while ensuring the preservation of the systems and resources that these needs depend on for future generations. Carter and Rogers (2008). Social efficiency and social sustainability are closely related concepts, as the efficient use of resources can enhance the overall resilience and stability of society. By ensuring equitable resource allocation and meeting everyone's needs, social efficiency can contribute to the long-term viability and flourishing of communities. This supports the objectives of social sustainability. Social efficiency is, in essence, a crucial element of social sustainability because it works to protect the welfare of present and future generations. Fahimeh et al. (2023).

Fahimeh et al. (2023) conducted the study "Social efficiency forecasting based on social sustainability practices in the service supply chain" and found that "employees' health and safety systems," "employees’ environmental and social performance," and "customer safety management systems" were the practices that had the greatest impact on social efficiency in hospital supply chains. The study also emphasised how important it is to take into account social sustainability strategies that service providers can afford and schedule. We intended the study's conclusions to enhance our understanding of social efficiency in long-term service supply chains and encourage further empirical research in other service industries to compare the effectiveness of social praLeire et al. (2018) conducted a study titled "The Social Efficiency for Sustainability: European Cooperative Banking Analysis". alysis" In European cooperative banking, the study found no trade-off between social and economic efficiency. This implies that reaching social objectives and achieving financial success are not inherently incompatible.

Despite scholars' emphasis on considering all three dimensions, research and practice have undervalued the social dimension of sustainability. "Eskandarpour et al., 2015; Xu & Gursoy, 2015a; Reefke & Sundaram, 2017; Torkayesh et al., 2021." However, there is evidence to support the claim that establishing and promoting social responsibility initiatives increases an organisation's profit by encouraging customers to buy its goods (Jayaraman et al., 2012; Xu & Gursoy, 2015b). As an illustration, research by "Graves and Waddock, 1994; Waddock and Graves, 1997; and Gryphon and Mahon, 1997" has shown that corporate social responsibility (CSR) improves the financial performance of businesses. Welford and Frost (2006) have shown how CSR can lead to lower costs by reducing waste, water, and energy consumption and utilizing raw materials more efficiently. According to Mackey et al. (2007), companies that practice social responsibility will optimise their market value. Wang et al. (2014) examined the effect of CSR on the corporate performance of the US telecommunications industry . In the healthcare industry, Khan et al. (2018a, 2018b) used confirmatory factor analysis (CA) and principal component analysis (PCA) to investigate the impact of social sustainability barriers. Schönborn et al. (2019) looked into the relationship between the financial performance and the corporate social sustainability culture using regression analysis.

These practices benefit the communities in which socially sustainable organizations operate. By adjusting their practices to align with the needs of the societal stakeholders, these organisations improve and augment their human and societal capital. Additionally, by advancing societal capital and assisting stakeholders in understanding the motivation behind their actions, they provide value to society and a variety of stakeholders. Dyllick and Hockerts (2002). Scholars and professionals have observed that, compared to the other three sustainability factors—environmental, economic, and social—social sustainability has received less development, practice, and discussion (Mani et al. 2016; Vallance et al. 2011). The unsettled nature of industries' efficiency is a significant concern; there is a gap in the literature on industrial efficiency, at least in terms of the social perspective of efficiency (Goiria et al. 2017; Bibi et al. 2018). We base our strategy on ongoing contributions in this field.

In the current context, we understand the concept of social efficiency as the balance between allocating resources to an organization's objectives and generating societal value through their use, following the principles of the Pareto social optimum. (Chang A F 2000; Elkington J 1994). Equity and outside finance are examples of such resources, while loan amounts, clientele, or economic sustainability can benefit stakeholders (Belki et al. 2016). In this context, we conceptualize an organization as a consortium of stakeholders united by a shared objective; consequently, we measure the social efficiency of an organization by the profits it generates for its stakeholders, while subtracting any unfavourable externalities (Freeman 1984; Galema & Koetter 2016; Chortareas et al. 2013).

It might be challenging for managers to examine an industry's sustainability accomplishment from the perspective of the social component. Aliakbari et al., 2019. Currently, industrial managers use the majority of business models that include cost-related metrics and quantitative criteria. However, it is not explicitly promoted to achieve social aims. Govindan et al., 2021. Some recent empirical studies are attempting to assess the social performance of industries such as “Khokhar et al. 2020; Yıldızbaşı et al. 2021; and Hendiani et al. 2021." To the best of our knowledge, no literature in the cement business has forecasted the impact of cement output on social performance. By taking care of these relationships, industrialists may be able to prioritise and budget for them consciously. Reefke & Sundaram (2017). Industrialists require an expert system that allows them to investigate the effects of their choice to implement various social practices on achieving social sustainability. According to Hussein et al. (2016) and Tseng et al. (2018),

This is a critical criterion in recent literature that merits researchers' attention in order to create more useful solutions. Researchers Wang et al. (2015) and Eskandarpour et al. (2015) have made significant contributions to this field. Researchers and practitioners note that, of the three sustainability features—environmental, economic, and social sustainability—the social aspect is comparatively little practiced, debated, and developed (Mani et al. 2016; Vallance et al. 2011). The existing body of literature highlights a notable absence of a comprehensive conceptual framework for evaluating and addressing social sustainability, specifically within the industrial and operations domain in developing nations such as India. Gopal and Thakkar, 2015; Dempsey et al., 2009.

2.3.1: Workers Health and Safety: Several literary sources have examined and addressed the health and safety of personnel in the cement industry. In any industrial process, employees may encounter various physical, chemical, and biological agents or substances that present significant health hazards . Three persistent risk exposures in the cement sector are dust, respirable crystalline silica dust, and noise (WBCSD, 2015). Environmental anxiety is also a concern because of rapid industrialization. Stafford et al., 2015 Cement production and processing are associated with several occupational hazards. (Rampuri, 2017). The generation of fine dust during various stages of cement manufacture, particularly in crushing and packaging, poses the greatest risk Neghab et al., 2017. Cement dust, when breathed in or in contact with, irritates the skin and eyes because of its alkaline makeup. Erah et al., 2018. Everyone is aware that humans depend on the basic needs of air, water, shelter, and soil to survive. Nadeem et al., 2015. Breathing in cement dust can have a number of effects on the respiratory system, according to Nikhama et al. in 2022. There is a consistent connection between the exposure and symptoms such as phlegm, cough, wheezing, and shortness of breath. Bianchi,2007 Cement production generates significant volumes of SO2, NOx, and CO. These pollutants are harmful to human health. Bermudez, 2010. The most vulnerable populations are believed to be small children, the elderly, and those who have underlying respiratory problems like bronchitis, emphysema, or asthma Etim et al., 2021.

Ensuring the safety and health of cement industry employees is a critical issue, and many businesses agree that the entire sector should prioritize this area. In comparison to other industries like petrochemicals and petroleum refining, the cement industry has a greater rate of fatalities and injuries WBCSD, 2013. Although executives think that training is the most important safety intervention, Nahrgang et al., 2010 argue that businesses should think about making their workplaces more welcoming to workers. Educated and well-trained workers, whether employed in cement factories or further up the value chain at construction firms that use the product, are essential to the sustainable manufacture of cement. Reducing the amount of energy and raw materials used while still meeting quality, presentation, and price standards will only be possible with highly effective training programs in the future, when there will be a huge demand for cement as a building material Schneider et al., 2011.

Additionally, it is critical that state environmental officials possess the practical ability to guarantee that businesses engage in co-processing without jeopardising the well-being of employees and communities residing nearby. An investment in personnel and facilities to boost these institutions' institutional capability seems important to mitigate this problem "Lamas et al., 2013; Pinto Junior et al., 2009". The cement manufacturing will only be able to more diminish the ecological impact of its processes and its goods in their final applications with experience and know-how, as well as ensure the security of the employees and the communities existing around the plants "Milanez, 2007; Pinto Junior et al., 2009; Schneider et al., 2011". An evaluation of the literature indicates that further research is necessary to comprehend how cement industry employees view sustainability, including co-processing, workplace safety, community transparency, and active citizen participation in decision-making.

The demographic groups most uncovered to cement dust and other emanations are the workers at the production site, residents of the adjacent villages, and children attending schools within the pollution zone. Humphreys et al., 2011. Due to cement factory emissions, there is a strong correlation between exposure to air pollution and several unfavourable health impacts (Bertoldi et al., 2012). To prevent illness, cement companies should supply an overcoat, gloves, and a mask (Logasakthi & Rajagopal, 2013; Yoganandan & Sivasamy, 2015). For its employees, vendors, and neighbours of its operations, the cement industry should place a high emphasis on health and safety (Tomar, 2014). The company should consistently and effectively carry out risk assessment and incorporate its health and safety policy with other corporate rules (Cankaya S, 2015).

2.3.2 Equity:

People frequently regard the objectives of social efficiency, justice, and diversity as mutually reinforcing aims. Social efficiency is a concept that refers to the optimal circulation of resources and opportunities within a society with the goal of maximizing its total welfare and productivity. Arrow, K. J. (1951). Pigou, A. C. (1920) centres the concept of equity on the objective of ensuring impartiality and righteousness in the allocation of resources and opportunities. Conversely, diversity places emphasis on the incorporation and portrayal of diverse demographic groups. The presence of diversity within a social context has the potential to enhance overall efficiency by promoting the development of innovative ideas and establishing a climate conducive to creativity. Rawls, J. (1971).

The convergence of varied viewpoints, backgrounds, and experiences has the potential to foster enhanced innovation and decision-making capabilities, hence enhancing overall social efficiency. The presence of diversity within a social context has the potential to enhance overall efficiency by promoting the development of innovative ideas and establishing a climate conducive to creativity. Sen, A. (1980). The convergence of varied viewpoints, backgrounds, and experiences has the potential to foster enhanced innovation and decision-making capabilities, hence enhancing overall social efficiency. The promotion of fairness and diversity has the potential to mitigate instances of prejudice and bias in society. Cox, T. (1994). Discrimination and bias pose significant obstacles to achieving social efficiency, as they engender inefficiencies by perpetuating exclusionary practices that prevent highly skilled persons from accessing opportunities based on irrelevant attributes such as race or gender. Feldstein, M. (1974).

The presence of more justice and variety within civilizations has the potential to yield economic advantages. The achievement of social efficiency is closely linked to the establishment of equitable access to education, employment, and opportunities for all individuals in a given society. Jackson, S. E., & Ruderman, M. (1999). This inclusive approach fosters a more productive and wealthy society, as it enables the full utilisation of human potential and the optimisation of societal resources. Manski, C. F. (1993). The pursuit of social efficiency, in the absence of due consideration for justice and diversity, may give rise to social unrest and pose challenges to long-term sustainability. The failure to address the needs and uphold the rights of marginalised groups can lead to social and economic instability, ultimately compromising long-term societal efficiency. Alesina, A., & La Ferrara, E. (2000). "Contributive parity" should be a crucial criterion in evaluating unequal labor structures and envisioning a future where technology can aid in promoting fair social cooperation. Celentano D. (2018).

International labour standards, such as the "Discrimination Employment and Occupation" Convention and the "Workers with Family Responsibilities" Convention, promote equal opportunity and treatment for all workers, including those with family responsibilities (Laci et al., 2017). Industries that employ more women can gain disproportionately from reducing gender inequality, as this can accelerate economic growth and increase value-added and labour roductivity. Bertay et al. (2020). A 10% increase in the average salary results in a 0.15% decrease in labor rights violations, thereby reducing job quality inequality. Marinescu & Sojourner (2020). Labor markets are gendered institutions, and while addressing discrimination against women, regulations can help balance efficiency and equality. Elson D. (1999). Collins et al. (2012) state that the goals of labor law are to safeguard fair treatment and job security, ensure equitable access to labor markets, and promote full employment and respectable employment. International labour laws and standards protecting workers' rights are essential for peace, sustainability, and the advancement of humanity. Klimenco, (2021).

2.3.3 Fair Labor:

The implementation of equitable labour practices, encompassing the provision of just compensation to workers and the establishment of secure working environments, has the potential to enhance the overall efficacy of the labour market (ILO). Treating workers fairly increases their motivation, productivity, and overall well-being, leading to higher levels of labor productivity. Fair labor practices align with the goal of social efficiency because they promote the welfare of workers and their families. Freeman, R. B., & Medoff, J. L. (1984). When workers receive equitable compensation and receive benefits like healthcare and retirement plans, their reliance on social safety nets decreases, thereby reducing the burden on government resources. 018). Promoting equitable labor practices can also serve as a catalyst for sustainable economic growth. Through the prevention of labour exploitation and the reduction of income inequality, societies have the potential to attain a more equitable distribution of wealth. Stiglitz, J. E. (2012). This, in turn, has the capacity to increase economic activity and enhance consumer spending. The inclusion of fair labour practice Ensuring the long-term sustainability of a system requires the inclusion of fair labour practices within the framework of social efficiency. The use of labor practices that exploit workers, such as the employment of children or the provision of unsafe working environments, has the potential to incite social upheaval and result in long-term economic and reputational harm to both firms and nations. According to Arrow, K. J. (1951), the principles of social efficiency and fair labor are inherently interrelated and promoting equitable labor practices within an economy can have a positive impact on social efficiency by improving overall wellbeing, fostering economic growth, and ensuring sustainability. Nevertheless, attaining an optimal equilibrium between these two objectives frequently necessitates meticulous examination of distinct economic, social, and cultural circumstances.

Under the FLSA of 1938, the lumber and seamless hospitality industries in the South were required to pay a minimum wage, but the process of adjustment varied depending on the industry. A. Seltzer (1997) The lumber and seamless hosiery industries in the South were subject to a minimum wage under the Fair Labour Standards Act of 1938, but the process of adjustment varied depending on the industry. Baumann et al. (2015). Supply chain structures, corporate social responsibility messaging, and the experiences of industrial workers collectively shape the concept of a fair wage in industrialised labour. Ban. Z (2018). The FLSA greatly raised the minimum wage and shortened work weeks in Southern industry, which increased worker productivity and decreased unemployment. Moloney, (1942). The Fair Labour Association encourages adherence to global labour standards in the supply chains for clothing and sportswear, but critics cast doubt on its efficacy and accountability because of its corporate-dominated governance structure and the fact that many of its member companies continue to struggle to comply. Macdonald, (2011). The administrator chose to divide authority between the cotton and woollen industries due to the inability of industry committees under the Fair Labour Standards Act to initially reach a consensus on a consistent definition of their respective industries. Dickinson, Z. (1939). The Fair Work Act 2009 fails to meet international labour standards, highlighting the need for governments to respect the autonomy of industrial actors in collective bargaining, as noted by McCrystal (2010). It is unclear how Australia's Fair Work Act 2009 will affect enterprise bargaining, but collective bargaining may promote workplace justice. Gollan, P. (2009).

The Fair Labour Standards Act of 1938 established general minimum wages and maximum work hours with the goal of preserving a minimal standard of living required for employees' general health, productivity, and well-being. Ritcher, I. (1943). The FLSA of 1966 only slightly decreased overall employment, but significantly raised wages. Bailey et al. (2021). The FLSA, which raised the minimum wage and decreased the maximum work week, had an impact on industrial productivity. Moloney, J. (1942). With a greater effect in the South, the Fair Labour Standards Act reduced the percentage of men and women working more than 40 hours per week by at least 18%. Costa, D. (1988). All full-time and part-time employees are subject to the minimum wage, overtime compensation, recordkeeping, and youth employment requirements set forth by the Fair Labour Standards Act Cline, T. (1986).

2.4 Government policies for Sustainability of Cement Industry

The cement industry's operations significantly contribute to international environmental challenges, accounting for a sizeable portion of carbon dioxide emissions worldwide. Schneider et al. (2011). Policies for sustainable development are therefore essential to reducing the sector's negative environmental effects. Rowe, G. (1991). These regulations promote the use of environmentally friendly methods, like cutting back on energy use, switching to alternative “raw materials and fuels”, and putting CCS technologies into action Bonnet, M., 2002. Governments and industry stakeholders can collaborate to reduce greenhouse gas emissions, lessen the effects of climate change, and encourage the switch to a more environmentally sustainable cement production process by enforcing regulations and providing incentives for sustainable practices. Howes et al. (2017).

Furthermore, sustainable development policies in the cement industry consider social and economic aspects alongside environmental ones. Socially, by addressing issues with noise pollution, land use, and air and water pollution, these policies put the welfare of the communities residing close to cement plants first. In order to ensure that local communities are involved in decision-making processes pertaining to cement production activities, they also stress the significance of stakeholder engagement. In terms of the economy, policies for sustainable development encourage efficiency and innovation in the industry, which drives investments in the study and development of greener technologies and stimulates employment growth. Sustainable development policies in the cement industry aim to strike a balance between social responsibility, profitability, and environmental stewardship by combining environmental, social, and economic goals.

Because of the cement industry's large social and environmental impact, it has come under increased scrutiny in recent years. Scholars and decision-makers have underscored the urgent need for sustainable development policies to effectively address these issues. The **National Clean Air Programme (NCAP),** which attempts to reduce air pollution and enhance air quality in urban areas across the nation, is one noteworthy initiative in this respect.

The implementation of the MWP in the cement industry has attracted attention as a way to improve worker livelihoods and address social inequality. Minimum wage laws help to reduce poverty and promote economic empowerment in local communities by guaranteeing that workers receive fair compensation for the labour they do. In the cement industry, an occupational **health and safety policy** is essential for protecting employees' health and reducing risks at work. Because of the nature of cement manufacturing, there are a number of risks involved, such as operating heavy machinery in high temperatures and dusty environments. The research will assess the impact of the aforementioned three policies on the cement sector in Kashmir.

2.4.1: National clean Air programme (2019):

The MoEFCC established the National Clean Air Programme (NCAP) in January 2019 with the goal of creating clean air action plans and reducing PM2.5 pollution in 122 cities by 20–30% by 2024 compared to 2017 (NCAP, 2019). On April 19–20, 2018, the State Government and the MoEFCC held a two-day stakeholder consultation to talk about NCAP. The state government and other stakeholders participated in a second stakeholder consultation on NCAP on May 21–22, 2018. The "State Environment Minister's Conference" held a thematic knowledge session on the "National Clean Air Programme" on June 4, 2018, at Vigyan Bhawan in New Delhi, as part of the five-day World Environment Day, 2018 celebration Ganguli et al. (2020). Its many goals revolve around addressing the increasing amounts of air pollution in cities. NCAP's primary goal is lowering air pollution, with a focus on particulate matter (PM10 and PM2.5) and other pollutants like carbon monoxide, nitrogen dioxide, sulphur dioxide, and ozone. The program's second goal is to improve data collection, analysis, and public dissemination by augmenting nationwide air quality monitoring. Thirdly, it places a strong emphasis on creating and implementing customised air quality management plans for various cities and regions, guaranteeing a methodical approach to lowering pollution levels. Lastly, by informing local communities about the health risks associated with poor air quality and involving them in initiatives to improve air quality, NCAP encourages public awareness and participation. Through these goals, the NCAP hopes to protect public health, advance sustainable development in India, and significantly improve air quality (NCAP, 2019).

The government is implementing the Nationwide Ambient Air Quality Monitoring Programme (NAMP). The network includes 307 cities and towns across 29 states and 6 Union Territories, as well as 703 manually operated stations. NAMP has designated four air pollutants—SO2, NO2, suspended particulate matter (PM10), and fine particulate matter (PM2.5)—for systematic monitoring at all sites. Located in 71 cities across 17 states, 134 Continuous Ambient Air Quality Monitoring Stations (CAAQMS) provide real-time surveillance of eight pollutants: PM10, PM2.5, SO2, NOx, ammonia (NH3), CO, ozone (O3), and benzene. PM2.5 refers to fine particulate matter with a diameter of 2.5 μm or less, whereas PM10 denotes inhalable coarse particles with a diameter ranging from 2.5 to 10 μm. Particulates are the most lethal form of air pollution due to their ability to penetrate the circulation and lungs deeply and unfiltered. The diminutive PM2.5 particles can penetrate deeply into the lungs, rendering them particularly dangerous .

The NCAP's primary goal is to meet the mandated annual average ambient air quality requirements in all national areas within a specified timeframe. The NCAP proposes a provisional national goal of a 20%–30% decrease in PM2.5 and PM10 concentrations by 2024, with 2017 as the baseline year for comparison. The National Clean Air Programme (NCAP) in India requires increased funding for urban local authorities, more regular reporting on emissions and pollution levels, and a transition from a city-centric approach to managing air quality at the airshed level (Ganguly et al., 2020). The National Clean Air Programme 2019 (NCAP) of India efficiently addresses air pollution, leading to a decrease in greenhouse gas emissions and an enhancement in overall air quality (Anil Kumar et al., 2021).

2.4.2: Minimum wage policy

The minimum wage is the lowest remuneration an employer is obligated to pay employees for work performed within a certain period, which cannot be reduced by a collective bargaining agreement or an individual contract. (ILO) . Since its inception in 1919, the issue of minimum wages has been a significant concern for the ILO. The Preamble of the ILO Constitution demanded an immediate improvement in working conditions, including "the provision of an adequate living wage," based on the assumption that social justice is the foundation for establishing a lasting and universal peace. Around the world, a variety of minimum wage systems exist, each employing different approaches tailored to the unique requirements and preferences of each nation. Minimum wage systems range from extremely basic ones that apply a single rate across the nation to highly sophisticated ones that establish multiple rates based on industry, occupation, and/or location, among other factors.

Even though India was among the first developing nations to implement minimum wages, its system is still among the most convoluted worldwide. The 1948 law mandates the "appropriate government" to set minimum wage rates for workers in various specified sectors. In practical terms, this means that any enterprises operating under a railway administration, such as mines, oilfields, large ports, or corporations founded by the central government, are required to pay government-mandated minimum salaries to state governments. Conversely, establish all other rates via the formation of tripartite advisory councils consisting of representatives from the government, employers, and workers. States establish the minimum wage's impact on workers based on the number of "scheduled employments." The original Minimum Wage Act of 1948 mandated that governments protect workers in 13 specified occupations identified as industries not influenced by collective bargaining, hence rendering them particularly vulnerable to inadequate compensation and abuse. Workplace Bureau, 2005. Nonetheless, the Act also empowered state governments to expand this list, resulting in one or more Indian states encompassing approximately 300 distinct industries. While several states, such as Orissa and Tamil Nadu, have significantly expanded coverage, others, such as Mizoram and Manipur, have predominantly sustained it. As a result, the minimum wage rates in India vary significantly by state and by occupation within a state. The central government sets 48 minimum wage rates for distinct work categories; however, individual state governments set minimum wage rates for 1,123 job categories within the sectors designated in the Act. The 2009 numbers are accessible on the website of India's Labour Bureau. In other words, India has 1171 unique minimum wage rates. This partially reflects the vastness of the nation. Moreover, India is not unique in that it relies on occupational, sectoral, and/or regional minimum wages rather than a single national minimum wage. Increasing the minimum wage weakens its effectiveness as an antipoverty strategy because of its regressive value-added tax impact on consumer prices and its uniform distribution of benefits across the income spectrum (MaCurdy, 2015) .

In a competitive labor market, a legally binding minimum wage would improve the effectiveness of transfers to low-skilled workers and lower unemployment. Lee & Saez (2012). Germany uses minimum wages as a poorly targeted social policy tool to reduce poverty and welfare utilization. Bruckmeier & Bruttel (2020). The federal, state, and local governments set minimum wages jointly, resulting in a minor welfare gain. This policy's strategic complementarity depends on mobility and regional heterogeneity. Simon and Wilson (2021) In Indonesia, raising the minimum wage has a negative effect on employment in the urban formal sector, especially for young, female workers with less education, while improving opportunities for white-collar workers. Surayahadi et al. (2003) A straightforward interest group model better explains the historical trajectory of the minimum wage rate than any pursuit of particular objectives, such as increasing earnings or pulling families out of poverty. Sobel R. (1999). To maximise market efficiency, prevent the effects of unemployment, and support low-wage workers, a combination of a minimum wage and wage subsidy is a better policy. Husby R. (1993).

Raising the minimum wage appears to have no correlation with insurance, but it may lessen the unmet medical needs of low-skilled workers McCarrier et al. (2011). Laws pertaining to the minimum wage have the potential to re-distribute income in conjunction with income taxes, all without having a negative impact on unemployment. Sadka & Blumkin (2004). By balancing out labour market imbalances and counteracting distortionary effects, a minimum wage can help women and address gender-specific issues. Rubery & Grimshaw (2011). Raising the minimum wage negatively affects low-wage workers, as it leads to a decrease in their hours and employment, which in turn negatively impacts their earned income. . Neumark et al. (2004). Although they greatly compress the earnings distribution, minimum wages in Britain have no detrimental effect on employment. Dickens et al. (1999). Contrary to the widely accepted theory that labour demand curves slope downward, increases in the minimum wage in the fast-food industry may have led to an increase in employment Kennan (1995). A higher minimum wage distributes the benefits of higher earnings almost evenly across the income distribution and has a more regressive tax effect on consumer prices. MaCurdy, (2015).

Up to 17% of the wage increase was attributable to the minimum wage's effect on relocating low-wage workers from smaller, less productive businesses to larger, higher-paying ones. Dustmann, (2021). Minimum wage laws disproportionately affect women, causing them to have fewer employment opportunities and work fewer hours annually. Linneman, (1982). Early exposure to minimum wages can have negative long-term effects, particularly for Black individuals, such as reduced education and training, tenure, and experience in the labour market. Neumark & Nizalova (2004). A lack of competition in the labor market exacerbates the elusive employment effect. Manning, (2016). Increases in the minimum wage could have a limited and inconsistent impact on the economy, with employment declines and reductions in poverty eventually abating, according to Hill & Romich (2018).

2.4.3: Occupational health and safety:

“The Indian Constitution classifies labor under the concurrent list, allowing both federal and state governments to legislate on the matter while reserving certain topics exclusively for the central government. According to India's Allocation of Business Rules, the Ministry of Labour and Employment is responsible for workplace safety and health. The “Ministry of Labour and Employment of the Government of India”, along with the labour departments of each state and union territory, is responsible for safeguarding the health and safety of the workers. The Ministry obtains technical assistance for Occupational Safety and Health in the factory and port sectors from the “Directorate General of Factory Advice Service & Labour Institutes (DGFASLI) and the Directorate General of Mines Safety (DGMS)”, respectively. Several mechanisms, such as mine inspections, accident investigations, surveys, and the issuance of permits and exemptions, implement the requirements of the occupational safety, health, and welfare statute in mines. Additionally, DGMS implements non-statutory promotional initiatives, including the National Conference on Safety in Mines, the National Safety Awards in Mining, Safety Week observance, the Promotion of Self-Regulation through Internal Safety Organisation, and awareness programs (Ministry of Labour and Employment 2017) .

India has 569 coal mines, 67 oil and gas mines, 1,770 non-coal mines that file returns, and a substantial number of small mines, possibly exceeding 100,000, with minimal infrastructure, capacity, and size, collectively producing 89 distinct minerals. The mining sector in India employs over one million individuals directly on a daily basis. The incidence of fatal accidents and the average yearly mortality rate per thousand employed individuals are decreasing. The average number of fatal incidents in coal mines declined from 162 in 1981–1990 and 140 in 1991–2000 to 86 in 2001–2010, representing a reduction from three digits to two digits. The mortality rate in coal mines has also declined, decreasing from 0.34–0.33 during 1981–1990 and 1991–2000 to 0.27 between 2001 and 2010 . The frequent incidence of tragedies in coal mines, primarily underground, as well as in certain metalliferous mines, including those extracting granite, soapstone, and iron ore, is a significant cause for concern. In recent years, the frequency of explosion-related disasters has significantly increased. The incidence of severe mining injuries is consistently decreasing. Comprehensive investigations of accidents reveal disturbing patterns of causation (Rajamannikam, 2016).

The other measure of safety status could be the number of law violations found during inspections, which could indicate a pattern of recurring violations of the same kind. Additionally, mine workers must contend with a number of workplace hazards that negatively impact their health. Among the most significant ones are heat, humidity, noise, vibrations, dust, and so forth. According to surveys carried out by DGMS in a small number of mines, many of the people who work there have occupational illnesses like silicosis, coal miners' pneumoconiosis, noise-induced hearing loss, etc. Due to the severe shortage of Occupational Health Inspectors, it is imperative to conduct a comprehensive occupational health survey that complies with international standards and guidelines. This will aid in assessing the current situation and pinpointing the crucial areas related to occupational health. The state of occupational safety and health (OSH) in India is complex, presenting both opportunities for improvement through primary health care ecosystems and corporate social responsibility initiatives, as well as obstacles such as insufficient policy, legislation, and infrastructure. Rajesh, (2018). India's extensive workplace safety and health laws only address four industries, falling short of international and ILO requirements (Roy.P., 2018). India needs to catch up with the rest of the world and enhance workplace safety, which means it needs modern occupational health laws, enforcement, and centres of excellence. Joshi & Smith (2002).

Due to exposure to noise, fumes, and dust, occupational diseases are common in the cement industry, emphasizing the need for better safety protocols and personal protective equipment. Rampuri, (2017). The primary causes of workplace accidents in Nepal's cement industries are worker shortcuts, shoddy housekeeping, and a lack of safety protocols; however, a lack of integrated safety plans and culture is the underlying cause. Mishra, (2019). Cement production has significant negative effects on the environment, human health, and safety, which emphasises how crucial it is to prioritise safe and healthy working conditions in order to stay competitive in the building industry. Cankaya & Cankaya (2015). Cement production has significant negative effects on the environment, human health, and safety, which emphasises how crucial it is to prioritise safe and healthy working conditions in order to stay competitive in the building industry. Tomar, (2014). Working at heights and using machinery are the primary sources of occupational hazards in the cement industry, making it necessary to put safety precautions in place and create a positive work environment to ensure employee wellbeing. Balochkhaneh et al. (2016).

Chapter III

Research Methodology

Conducting a research study necessitates a clearly defined scientific research process, as it aids in identifying the research issue. These approaches play a crucial role in addressing and validating the study's findings. This chapter provides an overview of the sampling strategy and the descriptive and analytical methodologies employed to accomplish the study's objectives, dubbed "Efficiency Analysis of the Cement Industry in Kashmir." We describe the study's methodological structure below, which enabled it to achieve its objectives.

- Description of the study area.
- Gap of the study
- Nature and source of data
- Need and scope
- Research objectives
- Methodological framework
- Analytical tools and Techniques.

3.1 Description of the study area:

The study took place in the scenic Kashmir Valley within the Union Territory of Jammu and Kashmir, situated between latitudes 33.2778° N and 34.5408° N and longitudes 74.0335° E and 75.5600° E. This region, renowned for its breath-taking scenery and rich cultural legacy, embodies a distinctive fusion of industrial activity and natural beauty. The valley is a perfect place to investigate the relationship between environmental sustainability and industrial development because of its varied geography, which includes vast agricultural fields, rolling hills, and lush forests. The socioeconomic background and climate of this area further influence the unique environment in which the cement industry functions.

The study, which focuses on the cement industry, includes all nine of the active cement mills in the Pulwama district, one of the valley's major industrial hubs. In particular, four of these plants are located in the Khrew area, and five of them are active in the Khanmoh area. These plants are vital to the local economy since they provide jobs and boost the area's industrial production. By incorporating all operational plants in the study, we ensure a thorough analysis that covers the entirety of the sector's environmental, economic, and social repercussions. Carefully examining these cement factories can provide a comprehensive picture of the cement industry's involvement in the Kashmir Valley, providing insightful information on their operational procedures, regulatory compliance, and community relations.

3.2: Gap of the Study:

While a number of studies have looked at the economic viability, environmental effects, and social dimensions of the cement industry, it is clear that there is a distinct lack of region-specific research that fully integrates these factors. The majority of research ignores the combined impact of economic, social, and environmental aspects on the industry's overall sustainability in favors of concentrating on a single component, such as productivity or environmental problems.

Furthermore, the application of the MPI and DEA in assessing the effectiveness of cement plants in Kashmir remains restricted, despite their use in other areas. Comparatively, there is a dearth of research on the effectiveness of government policies in the local environment and their impact on sustainability and regulatory compliance. By offering a comprehensive analysis of the cement sector in Kashmir and addressing the interplay of social, environmental, and economic issues along with policy implications, this study seeks to close these gaps.

3.3: Nature and sources of data:

We accomplished the study's objectives by combining primary and secondary data. In order to provide a thorough understanding of the cement sector's impact on the local environment and economy, the research uses a mixed-methods approach that integrates both qualitative and quantitative techniques. The study's structure addresses four main objectives, each addressing a different set of collection techniques. We gathered secondary data for the first and third objectives from various government offices and agencies. These include the Department of

Industries and Commerce, which provided data on industrial output, economic contributions, and employment statistics related to the cement sector; the Department of Economics and Statistics, which provided economic indicators, demographic data, and other pertinent statistical information; and the Directorate of Health Services Kashmir, which provided health-related data, particularly regarding the effect of industrial activities on public health in the regions of Khrew and Khanmoh. The Department of State Pollution Control Jammu and Kashmir provided data on environmental regulations, pollution levels, and compliance records for the cement plants. The secondary data provided a fundamental understanding of the cement plants' operational context, regulatory environment, and socioeconomic and environmental effects.

We gathered primary data to fulfil the study's third and fourth objectives. We created a systematic questionnaire to gather first-hand information from a range of stakeholders, including government officials, employees, locals, and plant managers. The questionnaire addressed a wide range of subjects, including ways in which cement factories operate, strategies for managing the environment, precautions for health and safety, the advantages and disadvantages that the local population faces economically, and attitudes and perceptions of the cement sector. The primary data gathering technique utilized systematic random sampling to choose participants. Given the unique focus on these plants, the sample included key informants directly connected to the nine cement facilities in operation in Khanmoh and Khrew. This method made sure that the information gathered was pertinent and unique to the field of research. We conducted surveys and interviews with plant managers and a representative sample of workers to understand their working conditions and operational procedures. We also distributed surveys to locals to understand their perspectives on the impact of cement plants on their environment and health. Conversations with representatives of pertinent government agencies provided insights into industrial policy and regulatory compliance.

3.4 Need of study:

The cement industry greatly influences a region's economic development (Rusdianto & Siswanto, 2020). It creates immediate job possibilities in addition to fostering the expansion of other industries. To guarantee sustainable growth and reduce adverse effects on the environment and society, it is crucial to evaluate the effectiveness of the cement industry (Pan et al., 2021).

The need for this study arises from the lack of a thorough examination of the effectiveness of Kashmir's cement industry (Rusdianto & Siswanto, 2020). Furthermore, it is even more important to comprehend the efficiency of the cement business given Kashmir's distinct physical features, which include its hilly terrain and restricted accessibility. Examining the cement industry's social, environmental, and economic performance in Kashmir is part of the study's purview. The study aims to evaluate the economic efficiency by examining variables such as production costs, profitability, and resource utilization. The study will also scrutinize the impact of the cement sector's emissions, waste production, and resource use on the environment. Additionally, by analysing the cement industry's effects on employment, local communities, and social development, the study will assess the industry's social efficiency. Additionally, the study will assess how government policies contribute to the sustainability of Kashmir's cement sector.

3.5 Research objectives:

- To assess the economic efficiency of cement industry in Kashmir.
- To analyze the impact of cement industry on the environment in Kashmir.
- To evaluate the social efficiency of cement industry in Kashmir.
- To evaluate the role of government policies in the sustainability of cement industry in Kashmir

3.6 Research Hypothesis

(H0): There is no significant difference in the economic efficiency of cement plants in Kashmir, regardless of technology adoption or resource management practices.

(H1): There are significant variations in the economic efficiency of cement plants in Kashmir, with those adopting advanced technologies and optimized resource management practices demonstrating higher productivity.

(H0): The cement industry in Kashmir does not significantly impact the air quality in regions like Khrew and Khanmoh, and particulate matter (PM10) levels do not exceed environmental safety standards.

(H1): The cement industry in Kashmir significantly impacts the air quality in regions like Khrew and Khanmoh, with particulate matter (PM10) levels exceeding environmental safety standards and contributing to adverse public health outcomes.

(H0): The cement industry in Kashmir does not experience significant issues related to labor welfare, and occupational health, safety measures, and labor conditions do not negatively affect worker satisfaction or productivity.

(H1): The cement industry in Kashmir experiences significant issues related to labor welfare, with inadequate occupational health, safety measures, and labor conditions negatively affecting worker satisfaction and productivity.

(H0a): There is no significant association between demographic factors (age, gender, occupation) and awareness of policies (NCAP, Occupational Health and Safety, and Minimum Wage).

(H1b): There is a significant association between demographic factors (age, gender, occupation) and awareness of policies (NCAP, Occupational Health and Safety, and Minimum Wage).

(H0c): Government policies such as the Minimum Wage Policy (MWP), Occupational Health and Safety (OHS) regulations, and the National Clean Air Programme (NCAP) are consistently and effectively implemented across all cement plants in Kashmir, without significant variation in compliance.

(H1d): Government policies such as the Minimum Wage Policy (MWP), Occupational Health and Safety (OHS) regulations, and the National Clean Air Program (NCAP) are not consistently implemented, and there is significant variation in policy compliance across cement plants in Kashmir.

3.7 Methodological Framework:

This study used a variety of approaches to fully address each objective. Below is a list of the methods that align with the specific objectives of the research. These diverse methodologies guarantee a thorough investigation with a robust analysis that incorporates primary and secondary data sources, customized to match the unique needs of each research goal.

3.7.1 Objective 1: To assess the economic efficiency of Cement Industry in Kashmir.

3.7.1.1: Sample Selection: We have chosen to incorporate all nine of the cement plants that are currently operating in Kashmir in our research. These plants are located in Khanmoh and Khrew, two industrial areas. Currently in operation are four plants in the Khanmoh area and five in the Khrew area.

3.7.1.2: Period of the study:

Since cement plants did not provide the required operational data before 2021, we limited the analysis to this time period to ensure current and comprehensive data, enabling a more accurate assessment of economic efficiency using the most recent available information. We chose the three-year period of 2021-2023 to evaluate the economic efficiency of the cement industry in Kashmir.

3.7.1.3: Tools for Data Analysis:

1.3.1: Data Envelopment Analysis: DEA is a linear programming technique that examines numerous inputs and multiple outputs to determine the relative efficiency of a homogeneous set of decision-making units. Charnes, Cooper, and Rhodes (CCR) first presented the method of measuring the technical efficiency of DMUs in 1978 , and Banker, Charnes, Cooper (BCC) later expanded on it in 1984. The primary advantage of DEA is that it relies solely on input and output quantities for its information requirements. Estimating efficiency in relation to the highest observed efficiency, as opposed to average, is the main goal of using DEA. However, the deterministic (non-parametric) nature of DEA, which takes all deviations from the frontier to inefficiencies, makes conclusions based on DEA more vulnerable to estimating errors or other random noise in the data.

1.3.1.1: Envelopment Model with CRS:

The mathematical formulation of Data Envelopment Analysis (DEA) under the premise of Constant Returns to Scale (CRS) was presented by Charnes et al. (1978).

Let x_{ij} and y_{rj} denotes i^{th} input; i = 1, 2, 3, . . . m and r^{th} output; r = 1 , 2 , 3 , . . . s respectively of the j^{th} DMU; j = 1 , 2 , 3 , . . . n. Then multiplier form of CCR-model for estimating an efficiency of DMU_k is given as:

$$h_k(u,v) = M^{2x} \frac{\sum_{r=1} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}}$$

Sub to

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1; j = 1,2,3, \dots n \qquad (1.3.1.1)$$

$$u_r \ge 0; r = 1,2,3, \dots s$$

$$v_i \ge 0; i = 1,2,3, \dots m$$

In this context, ur and vi represent the unknown weights of the rth output and the ith input in the jth Decision-Making Unit (DMU), respectively, whereas hk (u; v) denotes the efficiency value of the kth DMU, which ranges from zero to one. The mathematical formulation of model (3.2.1) is expressed in fractional form and possesses an infinite number of solutions. To eliminate the fractional form in model (3.2.1), a transformation proposed by Charnes and Cooper (1962) is utilized. Consequently, with the aforementioned change, the linear representation of the mathematical model (1.3.1.1) is as below:

Sub to

$$\sum_{i=1}^{m} \nu_i x_{ik} = 1$$

$$\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} \nu_i x_{ij} \le 0, j = 1, \dots n \qquad 1.3.1.2$$

$$\mu_r, \nu_i \ge \epsilon r = 1, \dots, \text{s. and } i = 1, \dots, m$$

The mathematical model presented in equation (1.3.1.2) is in linear form; nonetheless, it is not suitable for resolution using the DMU technique, necessitating the application of duality principles in linear programming. The usual version of the envelopment model is as follows:

$$\theta^* = \text{Min } \theta_k$$

Sub to

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{rk}; r = 1, \dots s$$

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta_k x_{ik}; i = 1, \dots m$$

$$s_r^+ \geq 0, s_i^- \geq 0 \text{ and } \lambda_j \geq 0; j = 1, \dots n$$

Where s^+r and s^-i are output and input slacks respectively.

1.3.1.2: Envelopment Model with VRS: Through the addition of a convexity constraint in the CRR envelopment model, Banker et al. (1984) expanded DEA to the situation of VRS. The efficient DMU under review can be estimated using one of two DEA orientations. There are two types of orientations: input and output. The input-oriented envelope model is often solved by maintaining fixed output levels while minimising the input level.

Following is the DEA model for kth DMU in the case of VRS is input-oriented model given as:

$$\theta^* = \text{Min } \theta_k$$

Sub to

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{rk}; r = 1, \dots s$$

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta_k x_{ik}; i = 1, \dots m \qquad 1.3.1.2$$

$$\sum_{j=1}^{n} \lambda_j = 1; j = 1, \dots n$$

$$s_r^+ \geq 0, s_i^- \geq 0 \text{ and } \lambda_j \geq 0; j = 1, \dots n$$

Thus, DMUK is said to be efficient if and only if θ^*= 1 and all slacks must be zero i.e. $s_r^+ = 0$ and $s_i^- = 0$. If $\theta^* = 1$, but all slacks are not zero. Then DMU under evaluation is week efficient, and if $\theta^* \neq 1$, then the DMU under evaluation is inefficient .

1.3.2: Malmquist productivity Index: The amount index was initially introduced by Malmquist in 1953. It is the proportional adjustment required for one consumption bundle to achieve the equivalent utility level of a reference consumption bundle. Considering economies of scale was futile, as his quantity index was formulated within a consumption framework, where utility is predominantly observable. The Malmquist quantity index has been extensively utilized to assess productivity changes over the past decade, originating from the foundational research of Caves, Christensen, and Diewert (1982) and Nishimizu and Page (1982). The research by F/ire et al.

(1989), which illustrated the application of nonparametric linear programming methods to derive the Malmquist productivity index, has motivated this application . Caves, Christensen, and Diewert assert that this has ostensibly transformed the Malmquist productivity index from a theoretical construct to a practically applicable index.

Total factor productivity (TFP) analysis serves as an effective tool for assessing the performance of the cement industry by examining the allocation of resources in output production. Najam and Cleveland, 2003. The techniques utilized for examining TFP behaviour are predominantly dictated by the available statistical data. This study collected data from all nine cement plants operating in the Kashmir Valley, sourced from the Department of Economics and Statistics, Kashmir.

The MPI, with output direction, can be articulated using a distance function (d) as depicted in equation (1), utilizing observations at time (t) and (t + 1) :

$$MPI_o(y_{t+1}, x_{t+1}, y_t, x_t) = \frac{d_o^t(x_t, y_t)}{d_o^{t+1}(x_t, y_t)} \qquad (1)$$

This indicator quantifies the variations in total factor productivity (TFPCH) and denotes the productivity of the production point (xt +1, yt +1) relative to the production point (xt, yt). An MPIo number beyond 1 signifies an increase in TFP, whilst a value below 1 denotes a decline in this metric. This index is the geometric mean of two indices: one utilizing the technology of period (t) and the other of period (t + 1) .

The MPI formulation shown in equation (1) can be partitioned into two components, as delineated in equation (2): technical change (variation in the boundary between the two periods) and change in technical efficiency (proximity to the technological frontier) .

3.7.2: Objective 2nd "To analyse the impact of cement industry on environment in Kashmir".

3.7.2.1: Sample selection

In our analysis, we have opted to include all of the nine cement plants that are currently in operation in Kashmir. The industrial regions of Khanmoh and Khrew house these plants. There are four plants in the Khrew area and five in the Khanmoh area that are currently in use. Our analysis will be thorough and reflective of the cement industry's influence in this area. For a comprehensive understanding of the environmental, economic, and social repercussions of all operating plants, we want to research them all.

3.7.2.2: Period of the Study:

The period selected for this objective is 2014-15, 2015-16, 2016-17, 2017-18, 2018-19, 2019-20, 2020-2021, 2021-2022, 2022-23. Period prior to 2014 is ignored as industries were not monitoring the particulate matter emission before 2014.

3.7.2.3: Tools used for data analysis

- **Air quality Index**

The Air Quality Index (AQI) reports the daily air quality. It informs us of the air's cleanliness or pollution level as well as any potential health risks. The AQI focuses on potential health effects that breathing contaminated air can have on us a few hours or days later. The range of the AQI is 0–500. The level of air pollution and the associated health risks increase with an increase in the AQI value. An AQI value of 100 typically represents the national air quality standard for the pollutant, the threshold the EPA has set to safeguard public health in India. Generally, we consider AQI values under 100 as satisfactory. Table 1 illustrates that air quality becomes unhealthy when AQI values exceed 100, first for specific vulnerable populations and then for everyone.

Table 3.1: Air Quality Index (AQI) values indicate the degree of health risks associated with the air quality.

AQI	Air quality pollution level	Health Implication
0-50	Good	Air pollution is harmless, and air quality is considered satisfactory.
51-100	Moderate	Individuals with pulmonary conditions, such as asthma, along with those suffering from cardiovascular disorders, children, and elderly individuals, may encounter respiratory discomfort.

151-200	Poor	Prolonged exposure may cause discomfort in respiration, whereas brief exposure may induce discomfort in individuals with cardiac issues.
201-300	Very poor	Prolonged exposure may lead to respiratory illness. In those with pulmonary and cardiac problems, the impact may be more significant.
300+	Severe	May provide significant health risks to individuals with lung or heart conditions, as well as to healthy individuals experiencing respiratory problems. Adverse health impacts may manifest even during light activity.

Formula of AQI

$AQI_{pollutant} = pollutant\ data\ reading \div Standard \times 100$

AQIpollutant represents the AQI value for PM10 emissions, whereas the pollutant data reading indicates the measured emissions. The standard limit for PM10 is 100 µg/m³ over a 24-hour period and 60 µg/m³ annually.

The State Pollution Control Board (SPCB) oversaw the acquisition of the annual data from both study locations. We computed the Air Quality Index for both locations using annual data from 2017 to 2023. We utilized a 12-month breakdown to analyse the seasonal variations in AQI values. December, January, and February comprised the winter season; March, April, May, and June comprised the summer season; July, August, and September comprised the monsoon season; and October and November were the post-monsoon season .

Regression Analysis for Particulate matter and Diseases

Regression analysis was also used to look at the connections between particulate matter (PM_{10}) and a number of medical disorders, such as skin function, irregular heartbeat, lung function, and acute and chronic bronchitis. The aforementioned medical problems are considered dependent variables in this analysis, with PM_{10} acting as the independent variable. This method seeks to measure how variations in PM2.5 levels affect the frequency and seriousness of these illnesses.

The regression model used in this analysis is expressed by the following general formula:

$Yi=\beta0+\beta1Xi+\epsilon i$

Where:

- Yi represents the dependent variable (Incidence of specific diseases) .
- β0 is the intercept term, indicating the baseline level of diseases when PM_{10} is zero .
- β1 is the regression coefficient for PM_{10}, reflecting the change in the disease outcome for a unit change in PM_{10} .
- Xi represents the independent variable (PM_{10} levels).
- ϵi is the error term, accounting for the variability in the disease outcome not explained by PM_{10}.

We were able to ascertain the degree to which alterations in PM_{10} lead to modifications in the relevant health outcomes by utilising this regression model. Insights into the possible health hazards linked to particulate matter exposure were obtained by this quantitative assessment, which helped to influence public health policies and initiatives for reducing the negative health impacts of air pollution.

3.7.3: Objective 3rd "To evaluate the social efficiency of cement industry in Kashmir".

For this objective, we have employed a self-structured questionnaire to gauge the social efficiency of the cement industry. We divide the questionnaire into two distinct sections, with section one highlighting pertinent personnel information for the study. Background of Respondent. In section two questions regarding "workers' health & safety," "fair labor," and "equity," a Likert scale has been used.

3.2: Sample selection

Sr. No	Name of plant	Labors
01	Khyber Cements	140
02	Arco Cements	136
03	Khyber Ltd.	112
04	TCI	127
05	TCI Max	110
06	Saifco Cements	105
07	Valley cements	85
08	Cemtac cements	76
09	H.K Cements	47
		Total: 938

3.7.3.2: Sample Size Calculation

The sample size of the study is determined by Krejcie & Morgan (1970) , the said formula is used when population is known or finite.

Krejcie & Morgan (1970) formula:

$$s = \frac{X^2 Np(1-p)}{d^2(N-1) + X^2 P(1-P)}$$

- S= required samples
- X2 represents the chi-square table value for one degree of freedom at the specified confidence level (3.841) .
- N= Population size :
- **P=** the population proportion (assumed to .50 since this would provide the maximum sample size) .
- d= the degree of accuracy expressed as a proportion (.05) .

$$s = \frac{X^2 Np(1-p)}{d^2(N-1) + X^2 P(1-P)}$$

- S= (3.841) (938) (0.5) (1-0.5) ÷ (0.05^2) (938-1) + (3.841) (0.5) (1-0.5)
- = 3602.85 (0.5) (0.5) ÷ 0.0025 (937) + (3.841) (0.5) (0.5)
- = 3602.85 (0.25) ÷ 2.34 + 0.96
- =900.71 ÷ 3.3 = 272

Approximately: 272 sample size.

3.7.2.3: Sampling Technique: For this purpose, researchers have employed systematic random sampling for data gathering. Systematic random sampling, a probability sampling strategy, involves researchers determining a desired sample size from the population and employing a regular interval to select individuals from the target population for sampling . We determine the sampling interval by dividing the population size by the computed sample size.

In our case, we have a total population of 938 in 9 cement plants, and a sample size of 272. The nth term (interval) can be calculated using the formula:

N=n/ns

- Where 'N' is the total population
- ns is the desired sample size

- In our case N is 938 and ns is 272
- Plugging these values into the formula

n= 938/272 =3.548

Since the nth term must be a whole number, you would round it to the nearest whole number. In this case, rounding up would be more appropriate to ensure that you cover the entire population. Therefore, we use an interval of 4.

3.7.2.4 Questionnaire Validation:

A panel of ten experts, consisting of three industry professionals and seven academic academics, validated the questionnaire, guaranteeing a thorough examination from both theoretical and practical standpoints. Each expert received a hard copy of the questionnaire for careful review. We considered the experts' feedback when purifying the questions to confirm clarity, significance, and alignment with the study's objectives, ensuring the validity and reliability of the instrument. The thorough validation procedure improves the reliability and validity of the information gathered.

Content Validity Ratio (CVR): Validity refers to the extent to which an instrument accurately measures its intended construct. A CV ratio (CVR) is a numerical figure that reflects the validity of an instrument, as assessed by expert evaluations of content validity (CV). The CVR indicates the validity of the item. In the Content Validity Ratio, the researcher must solicit the opinions of a panel of experts regarding the items developed for the study's constructs. Content validity (CV) assesses the extent to which the items on the assessment instrument encompass the complete content domain. The researcher utilized the Content Validity Ratio to evaluate the 'Essential', 'Not Essential', and 'Not Useful' statements from the questionnaire.

- **Formula of CVR:**

The Formula for computation of CVR =

CVR= Ne– $\underline{N}$

Ne is the number of panellists identifying as an item ‘essential’

N= Total number of panellists

- If all the panel members marked any item as 'essential' CVR =1
- If none of the panel member marked any item as 'essential' CVR=0
- We have distributed the questionnaire through google forms and hard copies.
- We got the questionnaire validated through industry experts and academicians.
- We have calculated the CVR after getting the validation completed by the 10 experts.

Table 3.3: Content Validity Ratio

TABLE 1
Minimum Values of CVR and CVR_t
One Tailed Test, p = .05

No. of Panelists	Min. Value*
5	.99
6	.99
7	.99
8	.75
9	.78
10	.62
11	.59
12	.56
13	.54
14	.51
15	.49
20	.42
25	.37
30	.33
35	.31
40	.29

Reference:(Lawshe, 1975)

In our study questionnaire have been validate by 10 experts ,thus according to table if CVR is <0.62 the statements will not be accepted and vice-versa .Out of 59 statements ,50 statements are accepted because the 50 statements have CVR = or more than 0.62 in our study.

Table: 3.4: CVR

Workers Health & Safety Andre et,al (2018) Syed et,al (2013)			Equity and diversity Fahimeh et,al (2023) Amrinder & Puja (2018)			Fair labor Fahimeh et,al (2023) Amrinder & Puja (2018)		
Item Label	Ne	CVR	Item Label	Ne	CVR	Item Lab el	Ne	CVR
WS1	8	0.6	ED1	10	1	FL1	8	0.6
WS2	4	-0.2	ED2	10	1	FL2	10	1
WS3	10	1	ED3	10	1	FL3	8	0.6
WS4	8	0.6	ED4	9	0.8	FL4	8	0.6
WS5	10	1	ED5	8	0.6	FL5	7	0.4
WS6	3	-0.4	ED6	4	-0.2	FL6	6	0.2
WS7	9	0.8	ED7	10	1	FL7	10	1
WS8	7	-0.8	ED8	10	1	FL8	10	1
WS9	2	-0.6	ED9	10	1	FL9	8	0.6
WS10	10	1	ED10	10	1	FL10	8	0.6
WS11	10	1	ED11	10	1	FL11	9	0.8
WS12	10	1	ED12	10	1	FL12	10	0
WS13	10	1	ED13	10	1	FL13	8	0.2
WS14	10	1	ED14	10	1	FL14	2	-0.6
WS15	10	1	ED15	10	1	FL15	2	-0.6
WS16	10	1	ED16	10	1	FL16	10	1
WS17	10	1				FL17	10	1
WS18	10	1				FL18	10	1
						FL19	10	1
						FL20	10	1
						FL21	10	1
						FL22	10	1
						FL23	10	1
						FL24	10	1
						FL25	10	1

3.7.2.5: Validity and Reliability

We used exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) to assess the validity and reliability of our constructs .

- Exploratory Factor Analysis: It is a statistical method for distilling data into a more manageable set of summary variables and investigating the phenomenon's underlying theoretical framework. When your work lacks a scale and you need to create your own, you utilize exploratory factor analysis to delve into the variables .
- Principal Component Analysis: You can use this flexible statistical technique to distill a cases-by-variables data table down to its principal components, or key elements. A small number of linear combinations of the original variables, known as principal components, can account for the majority of the variance in all the variables (Gorsuch, 1988).

We applied three commonly used choice criteria to identify the components underlying the SE dimension .

- Factor Loadings: In the context of reflective measurement models, the term "outer loading" pertains to the estimated associations, represented by arrows, between a latent variable and its corresponding indicators. The evaluation measures an item's absolute contribution to its construct. According to Henseler et al. (2015), outer loads equal to or greater than 0.7 are considered quite satisfactory. Chin (1998) recommends a threshold of 0.5, and disregards any components with values below this threshold. We discarded all items whose outer loadings fell below the threshold value.
- Eigen Value: This is the total variance that each factor explains. We select factors with eigenvalues greater than 1 for further study.
- Explained: Cumulative variance displays the percentage of total variance in the data, as determined by

    Eigen value / number of items *100

3.7.2.6: Tools and Techniques:

We used appropriate statistical tools based on the requirements of the objective. We measured all three dimensions—workers health & safety, fair labor, and equity—on a five-point scale to evaluate social efficiency, and used confirmatory factor analysis and descriptive statistics through AMOS and SPSS.

Confirmatory Factor Analysis: Confirmatory factor analysis (CFA) is a statistical method used to check if a set of observed variables accurately measures the latent constructs (factors) that the variables are meant to measure .

Construct Validity: CFA frequently evaluates the construct validity of a measurement model. How successfully a test or instrument assesses the construct it is designed to examine is known as construct validity.

A variety of validity criteria, including the following, can be used to assess construct validity in CFA.

- **Convergent Validity**: This concept demonstrates a robust correlation between indicators, or observed variables, intended to measure the same construct. Average variance is extracted, and composite reliability is used to assess convergent validity at a common threshold of 0.5 and 0.7, respectively.
- **Discriminant validity:** This ensures that intended differences between constructions actually exist. Two common methods of testing discriminant validity are average shared variance and minimum shared variance. The value of AVE and MSV should be less than 0.80.

To make sure the measurement model fits the data well, use fit indices like the Chi squared test, the goodness of fit index (GFI), the non-normal fit index, the confirmatory fit index (CFI), and the root mean square error approximation (RMSEA) to check the overall model fit .

- **Chi squared test ($\chi 2$/df CMIN):** The observed covariance matrix and the covariance matrix implied by the model are compared in the chi-squared test to evaluate the model's overall fit . A non-significant chi-squared value ($p > 0.05$) indicates well-fitting models**.** However, the significance of the chi-squared value is dependent on the sample size, and bigger samples frequently provide significant chi-squared values.
- The Goodness of Fit Index (GFI) determines the percentage of the data's variance and covariance that the model can explain. rating that is closer to 1 indicates a better fit. The values range from 0 to 1. A satisfactory match is often defined as a value of 0.90 or better.
- **Non-Normed Fit Index:** After accounting for the degrees of freedom, NNFI compares the model's chi-squared value to that of a baseline model. Generally speaking, values fall between 0 and 1, with those greater than 0.95 signifying a good fit. In contrast to other indices, NNFI occasionally exceeds 1.0.
- **Confirmatory Fit Index:** CFI evaluates the model's fit by taking sample size into account and comparing the chi-squared values of the null and hypothesized models. A good match is indicated by values of 0.95 or above, with values ranging from 0 to 1.
- **Root Mean Square Error Approximation:** The Root Mean Square Error (RMSEA) measures the model's ability to fit the population covariance matrix with optimally

specified but unknown parameter estimates. A value less than 0.05 indicates a good fit, a value between 0.05 and 0.08 indicates a moderate fit, and a value above 0.10 suggests a bad fit . Usually, a range of conceivable values is given along with an associated confidence interval.

3.7.4 Objective 4th: "To evaluate the role of government policies in sustainability of cement Industry"

To effectively address our objective, we have strategically chosen three key policies: the National Clean Air Programme, focusing on environmental sustainability; the minimum wage policy, targeting economical sustainability; and "Occupational Health and Safety" regulations, prioritizing social sustainability . To evaluate the effectiveness of these policies, we designed a structured questionnaire encompassing awareness, information sources, implementation, and overall impact. The questionnaire was distributed to all 80 managers working in the selected cement plants.

3.79.4.1: Tools and Techniques: To evaluate the role of government policies in the sustainability of the cement industry , we employed several statistical tools and techniques, including the Chi-Square Test, Cross Tabulation, and Descriptive Statistics, using STATA and SPSS software. The Chi-Square test and cross tabulation was utilized to determine significant associations between categorical variables, specifically examining the awareness and descriptive statistics were used to analyse the implementation of the National Clean Air Programme, Occupational Health and Safety, and Minimum Wage Policy among industry stakeholders.

- **Chi Square Test:** One statistical technique to ascertain whether two categorical variables have a significant relationship is the Chi-Square test . The anticipated frequencies resulting from the null hypothesis, which states that there is no link between the variables, are compared with the observed frequency of occurrences in each category.

Formula,

$\chi 2 = \sum Ei(Oi - Ei)^2$

- $\chi 2$: Chi-Square statistic

- Oi: Observed frequency in each category
- Ei: Expected frequency in each category under the null hypothesis .

- **Cross tabulation:** By making a contingency table that shows the frequency distribution of the variables, cross tabulation is a technique used to analyse the relationship between two or more category variables. This makes it possible to look at how several categories overlap and finds patterns or relationships between them.

Descriptive Statistics :

Mean: After adding up each value in a dataset and dividing the total number of values, the mean, sometimes referred to as the average, is a statistic used to describe central tendency .

Formula:

- For sample: $\bar{x}=n\sum xi$
- For a population: $\mu= \sum xi \backslash N$

- $\bar{x}$ or μ: Mean
- xi: Individual data points
- n: Number of observations in a sample
- N: Total number of observations in a population

Standard Deviation: The standard deviation is a dispersion statistic that shows how much a single data point deviates from the dataset mean.

Formula,

- For a sample: s= $\sqrt{\sum(xi - \bar{x})2} \div n - 1$
- For a population: σ= $\sqrt{\sum(xi - \mu)2 \div N}$
- s or σ: Standard deviation
- xi: Individual data points
- $\bar{x}$ or μ: Mean

Objectives	Tools Used	Reasons	Limitations
O1	DEA, MPI	DEA helped find and fix inefficiencies by evaluating how well businesses turn inputs into outputs. Using MPI, productivity variations over time were monitored, accounting for both technology advancements and efficiency gains. When combined, they provide a transparent picture of both present performance and long-term economic effectiveness.	DEA and MPI offer insightful information, but they are not without restrictions. With limited sample sizes, DEA may exaggerate efficiency since it is susceptible to the quality of the data. The short analysis period in this study due to data constraints restricts the ability to capture long-term production patterns, which is necessary for MPI, which requires consistent data across time. These elements could have an impact on the results' generalisability and robustness.
O2	AQI, Regression	PM10 concentrations were measured using AQI because it provides a consistent, transparent indicator of air quality, which makes it perfect for monitoring pollution levels from Kashmiri cement factories. Regression analysis, which successfully detects and measures the connection between pollution exposure and health outcomes like respiratory problems, was used to assess the influence of PM10 on human health.	The fact that AQI combines several contaminants may obscure the precise effects of PM10 alone, which is a major drawback. Additionally, it misses brief exposure spikes that have a big impact on health. Similarly, because regression analysis relies on secondary health data and may contain confounding variables, it is unable to definitively demonstrate causality even while it aids in identifying relationships between PM10 and health outcomes. For more accurate and causative findings, future studies could include longitudinal health data, individual exposure assessments, and real-time monitoring.
O3	CFA, EFA, Descriptive	CFA verified these frameworks, whereas EFA investigated underlying trends in workers' equity, fair labour, and health. A concise synopsis of the general circumstances and the opinions	The use of EFA and CFA is limited by the fact that they rely on self-reported data, which could be skewed or misinterpreted. Additionally, the factor structure could change

	Statistics	of the employees was given via descriptive statistics.	depending on the industry or circumstance. Although they are helpful for summarising data, descriptive statistics cannot reveal the root reasons of an issue. To improve validity and generalisability, future research should take into account mixed techniques, longitudinal studies, and larger, more varied populations.
O4	Chi Square, Cross Tabulation, Descriptive Statistics.	In order to find significant correlations between categorical data, the link between policy knowledge and demographic characteristics was investigated using cross-tabulation and chi-square testing. In order to evaluate the degree of policy implementation, descriptive statistics were employed, which gave a concise overview of respondents' opinions and indicated areas of high and low compliance.	Chi-square and cross-tabulation have the drawback of simply demonstrating correlations rather than causality, and they can be impacted by small or uneven sample sizes. Although descriptive statistics offer superficial insights, they are unable to elucidate the underlying causes of policy implementation gaps. To investigate causal links and contextual elements impacting policy compliance, future research should employ qualitative techniques and sophisticated statistical models.

CHAPTER 4

ECONOMIC EFFICIENCY OF CEMENT INDUSTRY

Assessing an organization's efficiency is essential to ascertaining its capacity to optimise outputs while minimising inputs, a fundamental metric of operational achievement. Efficiency analysis promotes competitiveness, helps find waste, and improves decision-making—all of which are important for long-term profitability and sustainability. Additionally, it enables businesses to create reasonable improvement targets and compare their performance to that of their competitors. Without these evaluations, businesses risk missing out on chances to maximise resource utilisation and adjust to shifting market conditions Farrel, 1957.

The economic effectiveness of Kashmir's cement factories from 2021 to 2023 will be assessed in this chapter. There will be two sections to the analysis: Section 1 will use the Malmquist Productivity Index to analyse the plants' total factor productivity, and Section 2 will use Data Envelopment Analysis (DEA) to evaluate each of the nine plants' efficiency.

4.1: Total factor productivity of cement plants

Table 4.1: Malmquist Indices, Summary of Annual means (Geometric mean)

Period	Efficiency change	Technical efficiency change	Pure Efficiency change	Scale Efficiency change	Total Factor Productivity Change
2021-2022	1.007	0.946	1.006	1.001	0.952
2022-2023	0.988	1.153	1	0.987	1.139
Mean	**0.997**	**1.044**	**1.003**	**0.994**	**1.041**

Table 4.1 shows how the Malmquist productivity index evolves, i.e. it presents the changes from one year to the next. These values are averages for the 9 cement plants. The year 2022 – 2023 are characterized by increase in productivity which are well above the average growth for the 2021-2022. We can say that for the year 2022- 2023 the average total factor productivity change is 13% (1.139-1= 0.139*100= 13.9%) this is due to an increase in technical efficiency change to the extent of 15%, pure efficiency remained stagnant . On average, total factor productivity increased by 4.1% over the two years. The cement plants saw a modest

improvement in technical efficiency and total factor productivity, with overall efficiency remaining relatively stable, but with some inefficiency due to suboptimal scaling.

Table 4.2 shows the Malmquist index results for the individual cement firms which reveal distinct patterns in efficiency, technological changes, and productivity growth over the study period. We can see with a remarkable 74% rise in total factor productivity, Khyber Cement stands out. This growth is primarily attributable to notable technological advancements and consistent managerial efficiency. The firm's great success is indicated by the highest technical efficiency change (1.724), indicating significant technological and resource utilization breakthroughs made by the company. However, Valley Cement and TCI saw significant drops in overall production, with drops of 6.6% and 18.4%, respectively. TCI's steep reduction was mostly caused by a large decline in technical efficiency (0.83), whilst Valley Cement experienced inefficiencies in size (0.953) and technology (0.98), indicating subpar capacity utilization. The difficulties in preserving operational effectiveness and technology competitiveness are exemplified by these two businesses. Minor improvements were seen in a few other firms' domains. For instance, total factor productivity changed by 1.08% to 1.7% for TCI MAX, Saifco Cement, and Cemtac Cement, all of which had modest increases in overall productivity. The improvements were primarily fueled by improved management techniques and, to a lesser degree, scale efficiency. However, a few companies, such as Arco Cement and HK Cement, experienced marginal drops in productivity as a result of small technology setbacks and less-than-ideal scale operations.

Table 4.2: Malmquist Indices, summary of Firm means (Geometric mean)

Firm	**Efficiency change**	**Technical efficiency change**	**Pure Efficiency change**	**Scale Efficiency change**	**Total Factor Productivity Change**
Khyber Cement	1.009	1.724	1.008	1.001	1.74
Arco Cement	0.996	0.989	0.998	0.998	0.985
Khyber LMT	1	1.016	1	1	1.016
TCI	0.984	0.83	0.984	1	0.816
TCI MAX	1.012	1.069	1.002	1.01	1.081

Saifco Cement	1.018	0.999	1.015	1.003	1.017
Cemtac Cement	1.019	0.995	1.016	1.003	1.015
HK Cement	0.986	0.986	1.004	0.982	0.972
Valley Cement	0.953	0.98	1	0.953	0.934
Mean	**0.997**	**1.044**	**1.003**	**0.994**	**1.041**

Overall, the data reveals that while certain firms Khyber Cement, in particular are benefiting greatly from technology developments, others experience productivity and efficiency stagnation, especially when it comes to technological innovation and scale efficiency. The findings highlight how crucial it is for the sector to adopt new technologies and practice appropriate scale management in order to maintain productivity development.

The DEA efficiency scores calculated by “R Software” for each of the plants for the years 2021, 2022, and 2023 are given in table 4.3. The plants can be divided into four types based on their DEA scores: efficient, inefficient, falling efficiency, and improving efficiency.

Efficient plants: Include businesses that earned a DEA score of 1 and showed no signs of inefficiency during the study's panel period. This suggests that these businesses are making the most out of their input set while optimizing their input resources. These businesses are Pareto-efficient and functioning at the cutting edge of efficiency. We have two plants in this list **Khyber LMT** and **Valley Cement**. These two plants operated under CRS and maintained perfect efficiency (1 in both CRS TE and VRS TE) for the entire three years, demonstrating ideal scale and completely efficient operations.

Table 4.3: DEA efficiency score for cement plants: 2021 to 2023

Year: 2021					Year: 2022				Year: 2023			
Firms	**CRS TE**	**VRS TE**	**SE**	**RTS**	**CRS TE**	**VRS TE**	**SE**	**RTS**	**CRS TE**	**VRS TE**	**SE**	**RTS**
Khyber	0.982	0.984	0.999	IRS	1	1	1	CRS	1	1	1	CRS

Cement												
Arco Cement	1	1	1	CRS	1	1	1	CRS	0.992	0.996	0.996	DRS
Khyber LMT	1	1	1	CRS	1	1	1	CRS	1	1	1	CRS
TCI	1	1	1	CRS	1	1	1	CRS	0.968	0.969	0.999	IRS
TCI MAX	0.977	0.996	0.981	DRS	0.976	0.995	0.981	IRS	1	1	1	CRS
Saifco Cement	0.965	0.972	0.994	IRS	0.98	0.983	0.997	IRS	0.999	1	1	CRS
Cemtac Cement	0.963	0.969	0.994	IRS	1	1	1	CRS	1	1	1	CRS
HK cement	0.99	0.992	0.998	IRS	0.98	0.982	0.997	IRS	0.962	1	0.962	IRS
Valley Cement	1	1	1	CRS	1	1	1	CRS	0.909	1	0.909	IRS

Inefficient plants: Companies classified as inefficient are those that exhibit constant inefficiencies over the course of the study, as indicated by a DEA score of less than 1. None of the plants in this investigation, meanwhile, were shown to be ineffective during the entire trial period. In some years, certain plants demonstrated full efficiency with a DEA score of 1, but in other years, their scores were lower. Consequently, it can be said that during the course of the investigation, none of the plants showed persistent inefficiencies.

Declining efficiency: Companies with declining efficiency are those whose total technical efficiency fell in 2023 as opposed to 2022. This group of plants includes Arco Cement and TCI.

Both had DEA scores of 1 in 2021 and 2022, indicating that they were entirely efficient. However, in 2023, their DEA scores dropped below 1, indicating that they had become inefficient.

Table 4.4: Input Slack

Qty. Million Tonnes

Year: 2021					**Year: 2022**				**Year: 2023**			
Firm	**Limestone**	**Gypsum**	**Coal**	**Clay**	**Limestone**	**Gypsum**	**Coal**	**Clay**	**Limestone**	**Gypsum**	**Coal**	**Clay**
Khyber Cement	424.279	0	0	0.239	0	0	0	0	0	0	0	0
Arco Cement	0	0	0	0	0	0	0	0	453.349	0.055	479.603	0
Khyber LMT	0	0	0	0	0	0	0	0	0	0	0	0
TCI	0	0	0	0	0	0	0	0	453.301	0	72.935	0.517
TCI MAX	432.685	0	582.752	0	84.556	0	0	0.661	0	0	0	0
Saifco Cement	538.584	0	403.37	0.324	209.022	0	0	0.037	5.697	0	0	0.034
Cemtac Cement	318.323	0	164.294	0.25	0	0	0	0	0	0	0	0
HK	215.0	0	231.	0.08	214.66	0	0	0.03	0	0	0	0

cement	7		12	3	6			1				
Valley Cement	0	0	0	0	0	0	0	0	0	0	0	0

Improving Efficiency: A company's ability to boost overall efficiency from 2022 to 2023 is considered an improvement in technological efficiency. In this instance, inefficiencies were demonstrated by four plants TCI Max, Saifco, HK, and Cemtac in 2021 and 2022, but they gradually decreased. Their DEA scores of 1 indicated that they had reached maximum efficiency by 2023.

An examination of the causes of inefficiency reveals that scale inefficiency has been more responsible for the companies' total inefficiency. Expanding their operations and production size is one way for businesses who are experiencing growing returns to scale to become more profitable. Businesses with diminishing returns to scale are inefficient because they overuse their resources.

Now that we know how many inefficient plants there are, we can determine how much they need to cut back on their inputs to become more efficient and make the best use of their resources. Table 4.4 illustrates the precise amounts of inputs that each firm should cut in order to attain efficiency in each of its years of inefficiency, based on the input slack data. Reductions are required in order to maximize resource utilization and enhance performance. Cement companies such as Arco Cement, TCI, TCI MAX, Saifco Cement, Cemtac Cement, and HK Cement must remove different proportions of limestone, gypsum, coal, and clay in order to increase productivity at certain times. For instance, Arco Cement must reduce coal, gypsum, and limestone in 2023, but TCI must reduce coal, clay, and limestone in the same year. For their operations to be in line with the best efficiency standards, these reductions are essential.

On the other hand, as seen by their constant efficiency over time, Khyber Cement and Valley Cement are making the best use of their resources. Their steady efficiency highlights their capacity to keep resource management at a high level without requiring additional cuts, establishing a standard for the best possible resource use in the sector.

Table 4.5: Summary of Peers

Year: 2021							
Firm	**Peers**			**Peer weight**			**Peer count**
Khyber Cement	3	4	9	0.782	0.077	0.141	0
Arco Cement	2			1			1
Khyber LMT	3			1			1
TCI	4			1			1
TCI MAX	9	2	4	0.387	0.456	0.157	0
Saifco Cement	4	9		0.25	0.75		0
Cemtac Cement	4	9		0.062	0.938		0
HK cement	4	9		0.187	0.813		0
Valley Cement	9			1			5
Year 2022							
Khyber Cement	1			1			0
Arco Cement	2			1			0
Khyber LMT	3			1			1
TCI	4			1			3
TCI MAX	3	4	9	0.143	0.429	0.428	3
Saifco Cement	7	9	4	0.451	0.207	0.341	0
Cemtac Cement	7			1			0
HK cement	4	7	9	0.344	0.437	0.22	2
Valley Cement	9			1			3
Year: 2023							
Khyber Cement	1			1			3
Arco Cement	1	7		0.808	0.192		0
Khyber LMT	3			1			0
TCI	7	1		0.923	0.077		0

TCI MAX	5			1			1
Saifco Cement	5	1	7	0.756	0.028	0.215	0
Cemtac Cement	7			1			3
HK cement	8			1			0
Valley Cement	9			1			0

The summary of peers presents the value and the reference of the organizations that are to be adopted. On the other hand, the percentage variance shows the peer weights to follow the reference organization's lead and become more effective. The number of times an effective organization serves as a model for ineffective organizations is indicated by the peer count. Table 4.5 shows us that in year 2021 With peer weights of 0.782, 0.077, and 0.141, respectively, Khyber Cement is encouraged to follow three peers (firms 3, 4, and 9). According to this, Khyber Cement can enhance its efficiency with 78% by following Khyber LMT's (firm 3) lead, with some help from TCI (firm 4) and Valley Cement (firm 9). As each of Arco Cement, Khyber LMT, and TCI has a peer count of 1, meaning that they are not frequently referenced by other firms, they each follow just one peer. On the other hand, TCI max follows 3 peers (Firm 2, 4 and 9) with peer weight of 0.387, 0.456, and 0.157 respectively so here TCI max will follow firm 4 which is TCI as by following this it will increase efficiency by 45%. It appears that TCI (firm 4) and Valley Cement (firm 9) are major sources of efficiency benefits for companies such as Saifco Cement, Cemtac Cement, and HK Cement. All three of these will follow Valley cement as it will enhance their efficiency by 75%, 93% and 81% respectively. Valley Cement is one of the most often used standards for other companies, having been used as an example by other businesses five times in 2021.

By 2022, the pattern will have changed, and since they are making effective use of their resources, Khyber Cement, Arco Cement, Khyber LMT, and Cemtac Cement won't need to follow anyone. But since TCI MAX depends on these three peers—firms 3, 4, and 9—for its 14%, 42.9%, and 42.7% respectively of its output, TCI MAX will choose to follow firm 4 or firm 9 in this case since doing so will increase its efficiency by 48%. Fascinatingly, Saifco Cement and HK employs a more diverse approach, behind firms 7, 9, and 4, with corresponding peer weights of 45%, 20%, and 34%, suggesting a strong reliance on Cemtac Cement (firm 7) at

45% and 43% respectively. As a baseline for three other companies, Valley Cement remains a noteworthy reference point.

Khyber LMT and Khyber Cement, TCI Max, HK, Cemtac cement will operated effectively in 2023 and won't require any guidance. Arco Cement will follow the first firm, Khyber Cement, as it will increase efficiency by 80%. TCI has the same references, which are firms 7 and 1, with peer weights of 92% and 0.07%. This clearly indicates that TCI should follow firm 7, as it will enhance by 92%. Saifco cement have 3 references which is firm 5, 1, and 7 with peer weight of 75%, 2%, and 21% it will follow firm 5 (TCI Max) for increasing its efficiency.

Due to its continuously excellent performance and efficiency, Valley Cement comes out as one of the most mentioned companies over the course of the three years. In response to shifting market conditions, companies such as Khyber Cement, TCI, and Cemtac Cement exhibit strategic shifts, alternating between depending on various peers. According to the peer count metric, certain companies, like Valley Cement and Cemtac Cement, are more often used as benchmarks than others, indicating their superiority in terms of operational effectiveness. In general, the interaction between peer weights and references provides information on how businesses move forward with increasing efficiency in the cement sector over time.

4.3: Discussion:

With a focus on nine cement plants, this study offers a thorough investigation of the productivity, efficiency, and operational dynamics of the cement industry in Kashmir. During the 2021–2023 period, these firms' performance and efficiency evolution were exposed through the use of the Malmquist Productivity Index and Data Envelopment Analysis (DEA), which yielded important trends and insights. Important conclusions suggest that although the industry's total productivity growth was just 4.1%, significant differences were seen across individual businesses. With a 74% increase in total factor productivity, Khyber Cement stood out among its competitors. This was mostly due to technological developments and steady managerial efficiency. On the other hand, because of scale and technological inefficiencies, companies such as Valley Cement and TCI had notable drops in productivity; TCI saw a sharp decrease of 18.4%.

The findings of the DEA demonstrate that over the course of the investigation, factories such as Khyber LMT and Valley Cement continued to function at maximum capacity and with the best possible use of their resources. Conversely, companies like TCI and Arco Cement experienced decreases in productivity, indicating difficulties in maintaining results. Furthermore, factories with effective management and scale adjustments included TCI MAX, Saifco Cement, and Cemtac Cement, all of which showed increases in efficiency over time. Peer benchmarking studies showed that companies such as Valley Cement and Cemtac Cement are often used as benchmarks by others, indicating superiority in their operational procedures. The report emphasises how crucial scale management and technological innovation are to the rise in productivity in the cement industry. Businesses that fell behind in these areas could not continue to operate efficiently; on the other hand, companies like Khyber Cement that welcomed innovation and maximized their size prospered.

There are a number of important elements that contribute to low efficiency in cement companies, all of which have an impact on total productivity and resource use. Poor resource management, which results in suboptimal utilisation of inputs like limestone, coal, and clay, is one of the main culprits. In addition to causing waste, this raises production costs without increasing productivity. Businesses must solve this by implementing improved monitoring and control systems to guarantee that inputs are used effectively and in the right amounts. The utilisation of antiquated technologies is another significant contributing element.

Many businesses still use outdated equipment and antiquated production methods, which use more energy and yield lower results. Modern, energy-efficient equipment upgrades and, when practical, automation can greatly increase productivity and save operating expenses. Low performance is also a result of operational inefficiencies. The manufacturing process can be disrupted and output levels reduced by disorganised processes, production delays, and frequent equipment outages. Businesses can lessen these problems by investing in predictive maintenance to cut downtime, implementing lean manufacturing techniques, and optimising processes. Furthermore, insufficient training and a shortage of skilled workers might impede effective process management and machine operation. Employees can be empowered to perform better and adjust to changing technology through regular training programs and skill development activities. Lastly, ineffective management techniques and inadequate planning frequently result in ineffective decision-making and resource allocation. Overall efficiency can be significantly increased by fortifying management systems with data-driven tactics, performance reviews, and improved planning tools.

The study concludes that maintaining productivity and efficiency in the cement business requires implementing new technology and optimizing scale. The disparity in performance amongst companies emphasises the necessity of focused approaches to deal with inefficiencies, especially in the use of technology and resource management. The results provide insightful information for industry executives and politicians who want to boost the sustainability and productivity of Kashmir's cement sector.

CHAPTER 5

IMPACT OF CEMENT INDUSTRY ON ENVIRONMENT

This chapter analyses secondary data sources to analyse how the cement industry affects the environment. There are two sections in this chapter. In the first portion, we gathered and used the AQI to analyse data on particulate matter (PM) concentrations for two important areas: Khanmoh and Khrew. We next looked at the graphical trends of PM concentration from 2014 to 2017. The effects of high PM concentrations on health are covered in detail in the second section. We obtained information from the Directorate of Health Services Kashmir about the main illnesses associated with high PM levels. The association between PM concentrations and the occurrence of these illnesses in both regions was examined using regression analysis.

5.1: Air Quality Index (AQI):

The daily air quality is reported using the Air Quality Index (AQI). It informs us of the air's cleanliness or pollution level as well as any potential health risks. The AQI focuses on potential health effects that breathing contaminated air can have on us a few hours or days later. The range of the AQI is 0 to 500. The level of air pollution and the associated health risks increase with an increase in the AQI value. The national air quality standard for the pollutant, which is the threshold the EPA has set to safeguard public health in India, is typically represented by an AQI value of 100. In general, AQI values under 100 are regarded as satisfactory. As shown in Table 1, air quality is deemed unhealthy when AQI values are above 100, initially for specific vulnerable populations and subsequently for all people .

$$AQI_{pollutant} = pollutant\ data\ reading \div Standard\ \times 100$$

Where $AQI_{pollutant}$ is the AQI value for PM10 emission, pollutant data reading is emission measured. The standard limit of PM_{10} for 24 hours=100µg/m^3 and for the year - 60µg/m^3.

It was obtained the yearly data from both study sites maintained by the state Pollution Control Board (SPCB). Using annual data, the Air Quality Index of both sites was calculated for the given period (2017 to 2023) of time. In order to examine the seasonal fluctuations in the AQI values, the 12-month breakdown was used. December, January, and February constituted the winter season; March, April, May, and June constituted the summer season; July, August , and

September constituted the monsoon season; and October and November constituted the post-monsoon season.

5.2: Annual variations of AQI:

5.2.1: Khrew Area

The 5.1 shows the amount of particulate matter (PM10) present in Pulwama's Khrew area between 2014 and 2023. Figure 1 is clearly showing from 2014 to 2018, PM10 levels disclosed a noticeable trend of gradual decline, with the lowest level recorded in 2018 at 188 µg/m³. The following years, however, show a notable reversal and a steady rise in PM10 concentrations, which peak at 238 µg/m³ in 2023. This change raises the possibility that human activity or local environmental factors affecting air quality have changed. The information suggests that in order to address the rising particulate matter levels in the Khrew area, it is critical to conduct ongoing monitoring, comprehensive investigations into the sources of pollution, and implement targeted measures. It is interesting to note that only the years 2018 and 2019 are indicated in yellow on the Air Quality Index (AQI) as being in the "Moderate" category. This designation implies that, when comparing air quality standards to PM10 concentrations, 2018 and 2019 are relatively better years. When compared to other years in the dataset, the yellow categorization denotes a period with lower health concerns due to a moderate level of pollution (Table 5.2).

Table 5.1: Concentration of particulate matter (PM_{10}) in Khrew area since 2014 to 2023

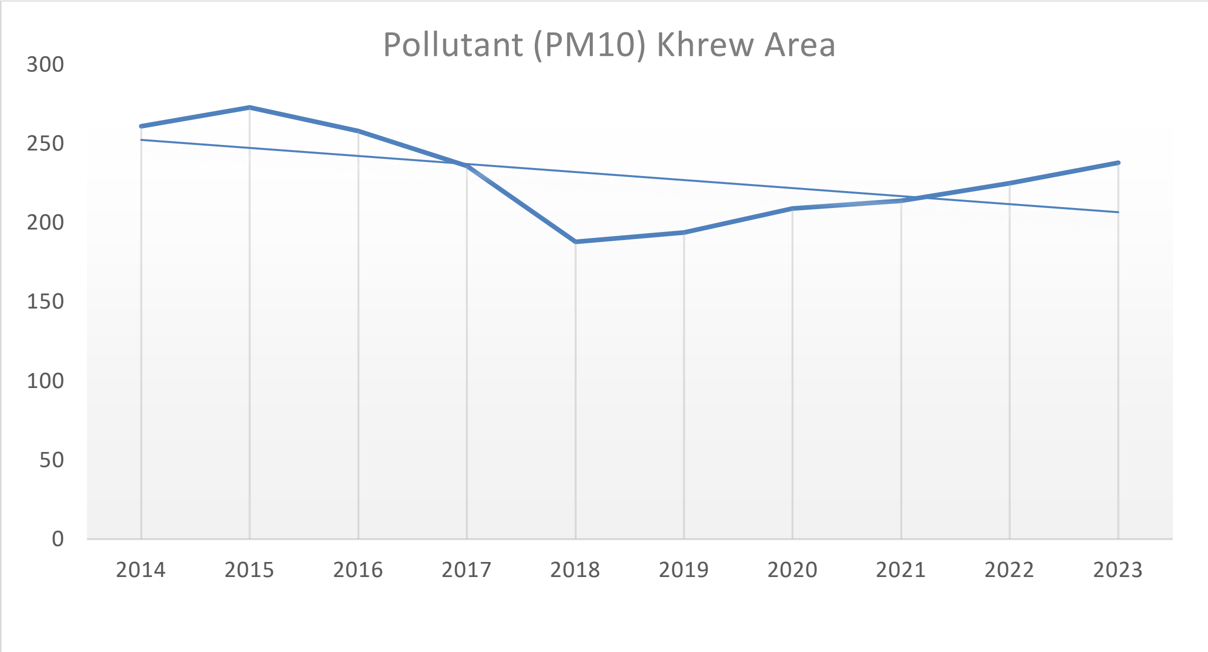
Year	**PM_{10} (µg/m^3)**	**Mean Value (AQI)**	**Permissible Limit (NAAQs) (µg/m^3)**
2014	156.78	261	60
2015	163.98	273	60
2016	154.76	258	60
2017	141.65	236	60
2018	112.55	188	60
2019	116.58	194	60
2020	125.85	209	60
2021	128.83	214	60

2022	135.10	225	60
2023	143.16	238	60

Table 5.2: Annual AQI color coding for the pollutant (PM10) of Khrew Area. (NAAQ)

Year	Particulate matter (PM_{10})	Calculated AQI	Overall category
2014	156.78	261	**Poor**
2015	163.98	273	**Poor**
2016	154.76	258	**Poor**
2017	141.65	235	**Poor**
2018	112.55	188	**Moderate**
2019	116.58	194	**Moderate**
2020	125.85	209	**Poor**
2021	128.83	214	**Poor**
2022	135.10	225	**Poor**
2023	143.16	238	**Poor**

Figure 5.1: Annual Trends of PM10 in Khrew area from 2014 to 2023.



5.2.2: Khanmoh Area

The table 5.3 presents the results of an analysis of the particulate matter (PM10) concentration in the Khanmoh area of Pulwama from 2014 to 2023. It shows a pattern of fluctuations without a distinct linear trend. PM10 levels rose significantly in 2016, peaking at 298 µg/m³. In contrast, 2019 saw a significant decline, with the concentration reaching its lowest point at 198 µg/m³. Khanmoh does not show a consistent declining trend in the last few years, in contrast to the Khrew area. Significant variations may be attributed to local factors, industrial activities, or meteorological conditions, as evidenced by notable spikes in 2020 and the absence of a clear trend from 2021 to 2023. According to the data, 2019 is a better year than 2018 in terms of PM10 levels, which is consistent with the Khrew area's trend. Thorough research into particular sources causing variations is necessary for the Khanmoh region's pollution control policies to be well-informed.

Table 5.3: Concentration of particulate matter (PM_{10}) in Khanmoh area since 2014 -2023

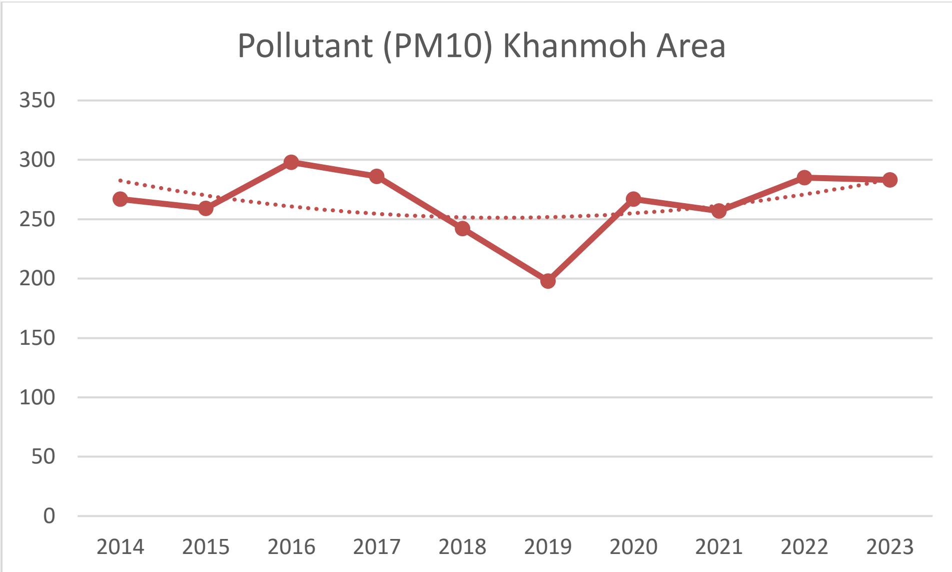
Year	**PM_{10}**(µg/m^3)	**Mean Value (AQI)**	**Permissible limit(**µg/m^3) **(NAAQs)**

2014	160.45	267	60
2015	155.89	259	60
2016	178.90	298	60
2017	171.87	286	60
2018	145.53	242	60
2019	119.8	198	60
2020	160.27	267	60
2021	154.72	257	60
2022	171.40	285	60
2023	170.31	283	60

Table 5.4: Annual AQI color coding for the pollutant (PM10) of Khanmoh Area. (NAAQ)

Year	**Particulate matter (PM_{10})**	**Calculated AQI**	**Overall category**
2014	160.45	267	**Poor**
2015	155.89	259	**Poor**
2016	178.90	298	**Poor**
2017	171.87	286	**Poor**
2018	145.53	242	**Poor**
2019	119.8	198	**Moderate**
2020	160.27	267	**Poor**
2021	154.72	257	**Poor**
2022	171.40	285	**Poor**
2023	170.31	283	**Poor**

Figure 5.2: Annual Trends of PM10 in Khanmoh area from 2014 to 2023



The Khrew and Khanmoh areas of Pulwama have PM10 concentration trends from 2014 to 2023, but it is difficult to determine with certainty which area has the worst air quality. The levels of PM10 in both areas show year-to-year fluctuations and variations, with some years exhibiting higher or lower concentrations. In Khanmoh, the patterns are more erratic with spikes in 2016 and 2020, whereas in Khrew, there is a discernible increase in PM10 levels starting in 2018. The comparison shows that local factors, industrial activity, and meteorological conditions can all have an impact on air quality issues, which are complicated. To determine which area consistently has worse air quality during the designated years, more thorough analysis would be required. This analysis would include additional air quality parameters and information on pollution sources.

5.3: Seasonal Variations:

In this paper, we investigate the seasonal fluctuations of particulate matter in Kashmir's cement industry, concentrating on two different locations: Khanmoh and Khrew. Expanding on earlier studies that examined yearly fluctuations, our research now focuses on the subtle variations throughout the four distinct seasons: summer (March, April, May, June), monsoon (July, August, September), and post-monsoon (October& November). The significance of seasonal variations in particulate matter levels cannot be overstated, as they not only enhance our comprehension of environmental dynamics within the area but also facilitate the development of focused approaches aimed at ameliorating possible detrimental consequences on air quality and public health. Our goal is to offer a thorough understanding of the seasonal dynamics of particulate matter in cement industries by investigating this temporal dimension. This will help to inform environmental management practices in Kashmir.

For the years 2014 and 2023, Table 6 displays the following AQI trends for the four seasons (summer, winter, monsoon, and post-monsoon):

5.3.1: Khrew Area:

The Khrew area's AQI was significantly worse during the winter and better during the monsoon in 2014.The following sequence was shown by the AQI in decreasing order: winter > summer > monsoon > post-monsoon. The entire text suggests that the AQI is decreasing, meaning that the winter months have the worst air quality and the monsoon has the best. The Khrew area's AQI was significantly worse during the summer and better during the monsoon in 2023. In decreasing order, the AQI value went through the following sequence: monsoon > summer > post-monsoon > winter.

5.3.2: Khanmoh Area:

The Khanmoh area's AQI in 2014 was significantly worse during the summer and better during the monsoon. In decreasing order, the AQI value went through the following sequence: summer > winter > post monsoon>Monsoon. The Khanmoh area's AQI in 2023 was significantly worse during the summer and better during the monsoon. In decreasing order, the AQI value was as follows: summer > winter > post monsoon > monsoon.

Table 5.5: Seasonal variation of the AQI of the Two areas of Kashmir for the years 2014 - 2023.

Area	**2014**	**2023**	**Remarks**
Khrew	W>S>M>PM	M>S>PM>W	The quality of the air improved overall. In winter of 2014, the worst AQI shifted to summer of 2023.
Khanmoh	S>W>PM>M	S>W>PM>M	The quality of the air improved overall. For both years, the summer months have the worst AQI.

W winter, S summer, M monsoon, PM post monsoon.

5.4: Clinical Data:

The Directorate of Health Services Kashmir provided the clinical data for this study, which was painstakingly collected between 2014 and 2023 by staff members stationed at the Khanmoh and Khrew health centers. This data collection focused on five major diseases linked to elevated particulate matter concentrations: skin infections, lung function impairments, irregular heartbeats, acute and chronic bronchitis, and infections of the skin. This extensive dataset provides an essential starting point for investigating the health consequences linked to high particulate matter levels. It provides information that is essential for comprehending and reducing the effects of environmental factors on public health in the Kashmir region.

5.5: Regression Analysis:

We used a regression analysis to assess how particulate matter (PM10) affected the occurrence of these illnesses. The purpose of the analysis was to find any meaningful relationships between the annual PM10 concentration levels and the number of cases of each illness that were reported. This method makes it possible to evaluate the possible health concerns connected to the region's high PM10 concentrations.

Table: 5.6: Regression Analysis between PM10 and Health (Khanmoh)

Variable	**R**	**R- Square**	**Significance**	**Standardized Coefficient Beta**
Particulate matter (IV) Acute Bronchitis (DV)	.480	0.230	0.04	0.480
Chronic Bronchitis (DV)	.816	0.665	0.00	.816
Skin Infection (DV)	.560	0.313	0.03	.560
Lung Function (DV)	.714	.509	0.01	.714
Irregular Heartbeat (DV)	.640	.409	0.00	.640

Predictors: (Constant). Particulate Matter PM10 (µg/m3)

Dependent variable: Acute Bronchitis, Chronic Bronchitis, Skin Infection, Lung Function, Irregular Heartbeat.

5.5.1: Relation between Exposure to emission and Health outcome:

It is critical to comprehend how particulate matter (PM10) emissions affect public health, especially in places like the Khanmoh site, which is home to five active cement plants. From 2014 to 2023, regression analyses were performed to evaluate the association between different health outcomes and PM10 exposure. The findings showed a strong relationship between PM10 levels and a number of medical disorders. Significant amounts of the variance in these health outcomes were attributable to PM10 exposure, as evidenced by the remarkably high R-squared values (0.665, 0.509, and 0.409, respectively) for chronic bronchitis, lung function impairment, and irregular heartbeat. Furthermore, all of the health outcomes' standardized coefficients (Beta) were positive, indicating a correlation between elevated PM10 levels and worsening health conditions. Moreover, the robustness of these results is highlighted by the statistical significance, with p-values for lung function, irregular heartbeat, and chronic bronchitis below 0.05. (Table 7) These findings highlight the urgent need for efficient methods to track and reduce PM10

Variable	**R**	**R- Square**	**Significance.**	**Standardized coefficients Beta**

emissions, especially in industrial areas like Khanmoh, in order to protect the public's health and lessen the burden of respiratory and cardiovascular diseases on the general populace.

Table 5.7: Regression Analysis between PM10 and Health (Khrew)

Particulate matter (IV) Acute Bronchitis (DV)	0.533	0.284	0.02	.533
Chronic Bronchitis (DV)	.709	.503	0.00	.709
Skin Infection (DV)	.442	0.195	.144	.442
Lung Function (DV)	.570	.324	0.01	.570
Irregular Heartbeat (DV)	.496	.246	0.03	.496

Regression analysis on data from the Khrew area, home to four cement plants, sheds light on the connections between different health outcomes and particulate matter (PM10) exposure. Results show significant correlations between PM10 levels and a number of health conditions over the study period (2014–2023). With a high R-squared value of 0.503, chronic bronchitis indicates that PM10 exposure accounts for roughly 50.3% of the variance in chronic bronchitis. Likewise, lung function impairment has a strong R-squared value of 0.324, suggesting that a sizable amount of the variability in lung function is related to PM10 levels.

Higher PM10 exposure is associated with an increased incidence of chronic bronchitis and a lower function of the lungs, according to the standardized coefficients (Beta), which further support these findings with positive coefficients for both chronic bronchitis and lung function. The robustness of the observed connections is further highlighted by the statistical significance of these relationships, with p-values of 0.01 for lung function and 0.00 for chronic bronchitis. Nonetheless, this research suggests that the correlations between skin infection and irregular heartbeat and PM10 exposure are not as strong. The R-squared values for these results, which are 0.195 and 0.246, respectively, indicate that PM10 exposure accounts for a smaller percentage of the variance. Furthermore, in comparison to lung function and chronic bronchitis, the standardized coefficients and p-values for these health outcomes suggest weaker and less statistically significant relationships.

All things considered, these results highlight how critical it is to track and reduce PM10 emissions, especially in industrial locations like Khrew, in order to address the serious health hazards associated with air pollution. Reducing PM10 exposure has the potential to lessen the burden of lung function impairment and chronic bronchitis, improving community well-being and public health.

Figure 5.3: Patients with different diseases from 2014 to 2023 years of the Khanmoh Health center

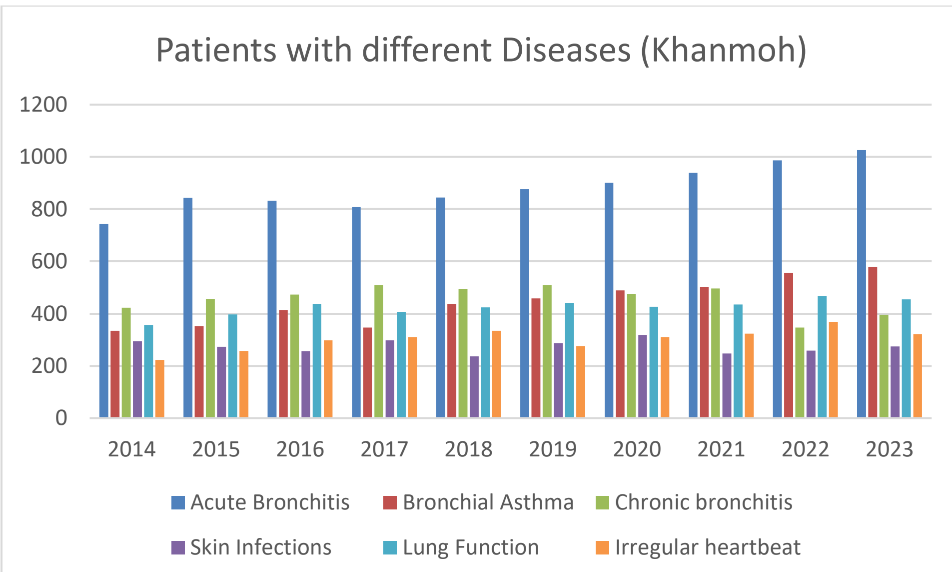
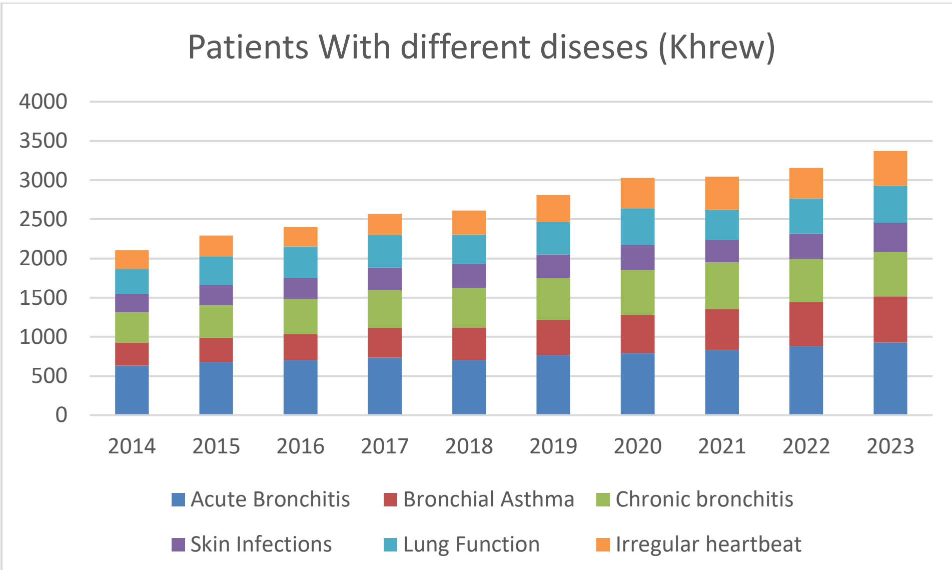


Figure 5.3 displays data from the Khanmoh area of Pulwama, which shows clear patterns in a range of health issues throughout time. From 2014 to 2023, the number of reported cases of acute bronchitis shows a continuous rising pattern. In a similar vein, bronchial asthma exhibits variability but generally experiences a rise, especially in the latter years. On the other hand, the prevalence of chronic bronchitis fluctuates initially before showing a falling trend starting in 2018, which may indicate an improvement in the condition's prevalence. While skin diseases can vary, they usually stay the same for the duration of the observation. On the other hand, data on lung function indicates a continuous decline over time, with yearly increments reported. Even while irregular heartbeats vary, they show a modest increase tendency, which is particularly apparent starting in 2019. These patterns shed important light on the Khanmoh area's health dynamics by drawing attention to problem areas like cardiovascular and respiratory health, which may call for more research and focused treatments.

Figure 5.4: Patients with different diseases from 2014 to 2023 years of the Khrew Health center.



Over a ten-year period, the data shown depicts the prevalence of different ailments in Pulwama's Khrew area. Important insights into the dynamics of the region's health can be gained by analyzing the trends depicted in figure 5. 4. Acute bronchitis prevalence shows a steady rising trend from 2014 to 2023, suggesting a gradual rise in cases that are reported. Analogously, bronchial asthma exhibits a consistent upward trend throughout time, indicating an increasing prevalence of respiratory problems among the populace. Contrarily, chronic bronchitis exhibits oscillations but often keeps a steady trend. There appears to be a minor increase in reported instances towards the later years, albeit considerable heterogeneity, which calls for more research into potential contributing factors. Skin infections show a variable pattern with no discernible trend, suggesting different prevalence levels over the course of the observation period. Access to healthcare services, cleanliness standards, and environmental factors may all have an impact on this variation (Table 5.7).

Data on lung function shows a worrying downward trend over time, with steady increases observed. This highlights the necessity for focused efforts to address this condition and raises the possibility of a decline in respiratory health. Last but not least, irregular heartbeat varies but generally indicates an increased trend, especially after 2020. This emphasises how crucial it is to keep an eye on cardiovascular health and put plans in place to reduce the risk factors that lead to irregular heartbeats in the general population. In general, these patterns highlight the significance of continued monitoring and intervention initiatives to meet the community's changing health requirements in the Khrew area, especially in the areas of respiratory and cardiovascular health.

A multifaceted strategy combining technological, governmental, and community-driven tactics is necessary to lessen the environmental impact of the cement sector in Kashmir, particularly in light of the high concentration of PM10 emissions. Adopting energy-efficient and clean technology, such electrostatic precipitators, baghouse filters, and dry kiln systems, is one of the best ways to drastically cut particulate emissions during production. Modernising production techniques improves long-term operational efficiency in addition to environmental performance. Another crucial stage is the installation of Continuous Emission Monitoring Systems (CEMS), which allow for the real-time tracking of air pollutants and guarantee accountability and prompt remedial action.

Simultaneously, regulatory efficacy must be strengthened by prioritising the enforcement of strict emission standards under the National Clean Air Programme (NCAP), which includes surprise inspections, frequent environmental audits, and sanctions for non-compliance. By creating thick plantations of dust-tolerant trees and shrubs around cement plants, green buffer zones can help capture airborne particles and enhance the quality of the local air. Adjusting operational intensity during these times can assist lessen the environmental load because pollution levels in places like Khanmoh and Khrew vary seasonally, peaking in the summer and winter, respectively.

Additionally, community involvement and early action can be promoted by incorporating health surveillance programs for workers and residents as well as efforts to raise awareness of the health concerns associated with pollution. For environmental regulations and cooperative monitoring systems to be implemented effectively, interagency collaboration between pollution control authorities, health departments, and local governing organisations is also crucial. Finally, the sector can be encouraged to shift to cleaner operations by offering financial incentives, such as tax rebates or subsidies, to businesses that implement eco-friendly technologies. When combined, these mitigating techniques and legislative changes have the potential to make Kashmir's cement sector more ecologically conscious and sustainable.

5.6: Discussion:

The operational footprint of nine cement plants in the Khrew and Khanmoh areas of Kashmir from 2014 to 2023 shaped the comprehensive analysis of annual and seasonal air quality trends, which reveals a complex interplay of factors influencing air pollution dynamics. The PM10 levels in Khrew show a complex pattern with varying values and no obvious linear trend. The data is punctuated by notable peaks in 2020 and 2016, which suggest potential influences from meteorological variations, industrial activities, and local conditions. But the notable drop in PM10 concentration in 2019 over 2018 points to the potential influence of coordinated efforts or cyclical environmental circumstances.

However, the following years show no discernible patterns, indicating the need for in-depth research into particular sources of pollution in order to guide focused mitigation efforts. Khanmoh, on the other hand, exhibits a more erratic pattern with notable spikes in 2016 and 2020, highlighting the necessity of customized pollution control strategies based on thorough source apportionment studies. Seasonal differences in air quality also emphasize the complex connection between pollution levels and weather patterns. The data shows a pronounced seasonal difference in Khrew, where the monsoons provide relief during the winter months and the winters themselves represent the worst air quality, as seen in 2014 and 2023. On the other hand, Khanmoh has a distinct seasonal pattern; summers there are normally marked by elevated pollution levels, with the monsoon season offering respite (a pattern that is repeated in 2014 and 2023). These results highlight the need for targeted, regionally-specific interventions that take seasonal variations and local environmental conditions into account in addition to addressing industrial emissions. Through the implementation of a comprehensive strategy that incorporates targeted mitigation measures, comprehensive data analysis, and stakeholder collaboration, policymakers can effectively address the multifaceted issue of air pollution in the Kashmir region, thereby preserving environmental sustainability and public health for future generations.

The data from Pulwama's Khrew neighborhood reveals noteworthy trends in a range of medical disorders during the previous ten years. A growing burden of respiratory disorders is shown by the steady rise in the prevalence of bronchial asthma and acute bronchitis in the general population. Although the tendency for chronic bronchitis remains mostly unchanged, there is a small rising trend in the later years. Skin infections show variable trends, indicating different prevalence levels. However, alarming patterns in the decline of lung function and irregular pulse are noted, highlighting the necessity of focused interventions to address the region's respiratory and cardiovascular health issues.

Chapter 6

Social Efficiency of Cement Industry

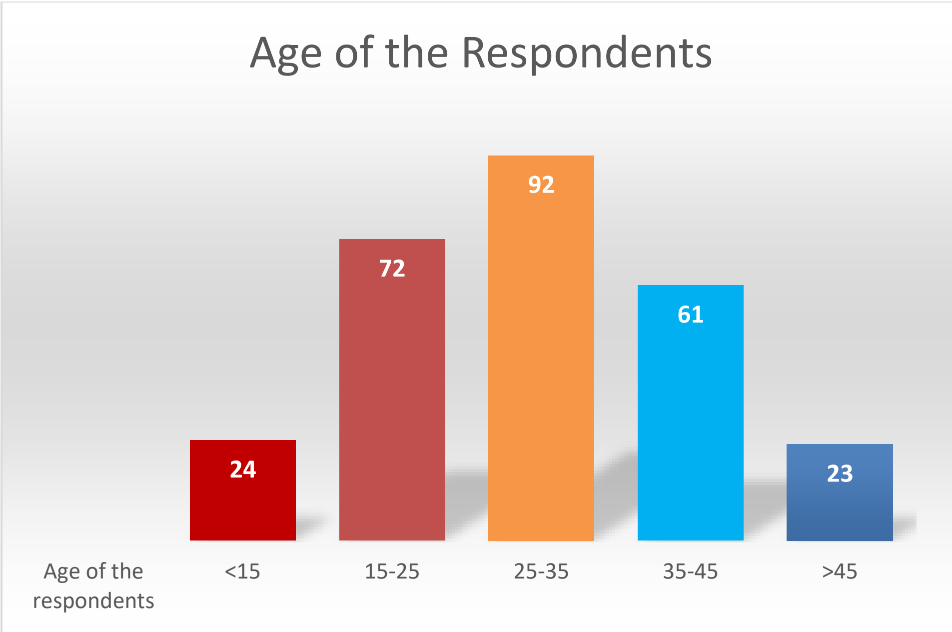
This chapter examines the social efficiency of the cement business, with a particular focus on the health and safety of employees, ethical labour practices, and worker fairness in Kashmiri cement factories. The chapter's first section covers the respondents' demographic profile and gives a thorough rundown of the traits of the workforce. The second section explores important topics including worker health and safety, maintaining ethical labour practices, and fostering worker equity, showcasing the success of the sector and regions in need of development in these vital areas.

6.1: Demographic profile of respondents

6.1.1: Age:

Figure 6.1 displays the age distribution of the respondents. Of the 92 respondents, the majority are in the 25–35 age bracket, suggesting that this group is the most represented in the cement plant workforce. Subsequently, there are 72 respondents in the 15–25 age group and 61 respondents in the 35–45 age group. There are only 24 responses under the age of 15, and there are only 23 respondents above the age of 45, making up the smallest group. The distribution shows a smaller number of people in the youngest and oldest age groups, indicating a predominance of workers who are younger to middle-aged.

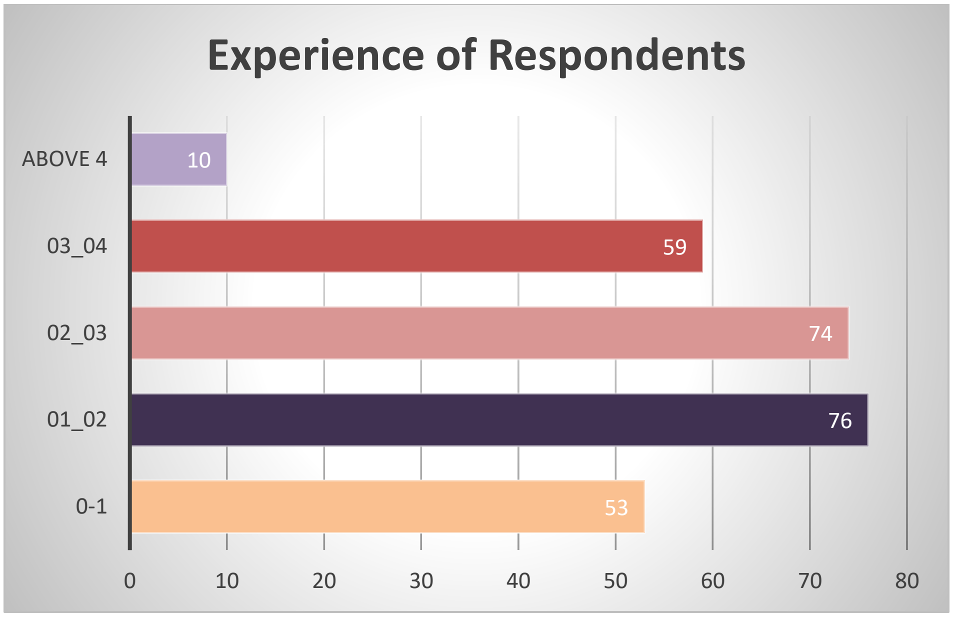
Figure 6.1: Age wise distribution of sample



6.1.2: Experience

Figure 6.2 illustrates the majority of the workforce has relatively short experience, according to the respondents' experience distribution. Those with 1-2 years of experience make up the largest category (76 responses), closely followed by those with 2-3 years of experience (74 respondents). 53 responders had less than one year of experience, and 59 had between three and four years. There are just ten people in the smallest group—those with more than four years of experience. This implies that the majority of workers in the cement plants are comparatively recent hires, with the proportion of long-term workers having significantly decreased.

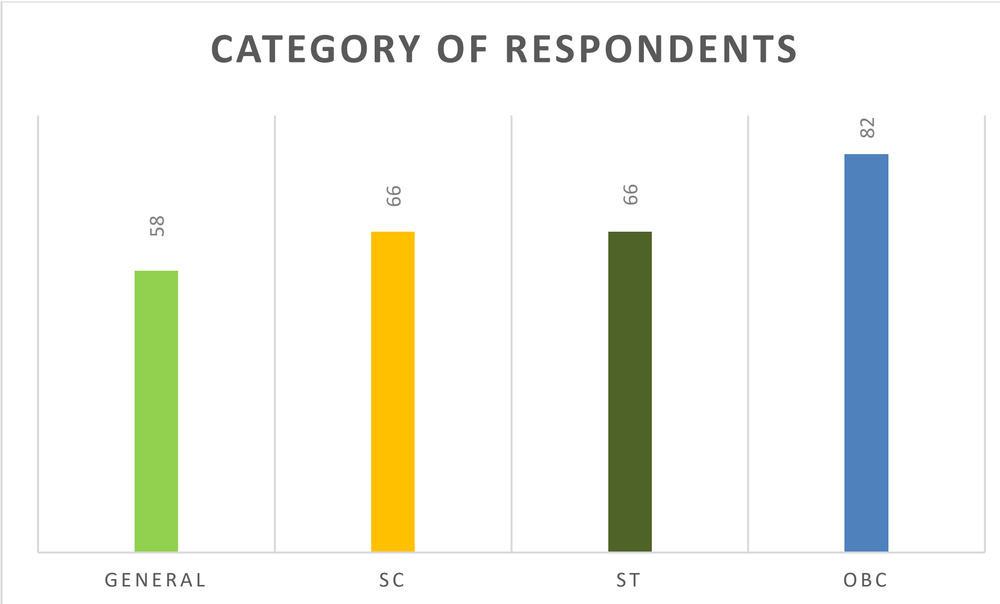
Figure: 6.2: Experience of respondents



6.1.3: Category

A diversified workforce is seen in the cement factories based on the category distribution of the responses. With 82 responders, the OBC (Other Backward Class) category had the largest representation. With 68 respondents apiece, the SC (Scheduled Caste) and ST (Scheduled Tribe) groups are evenly represented. With 58 responses, the General category is the one with the lowest representation. This distribution points to a fairly equal proportion of responders from all social categories, with a minor OBC majority.

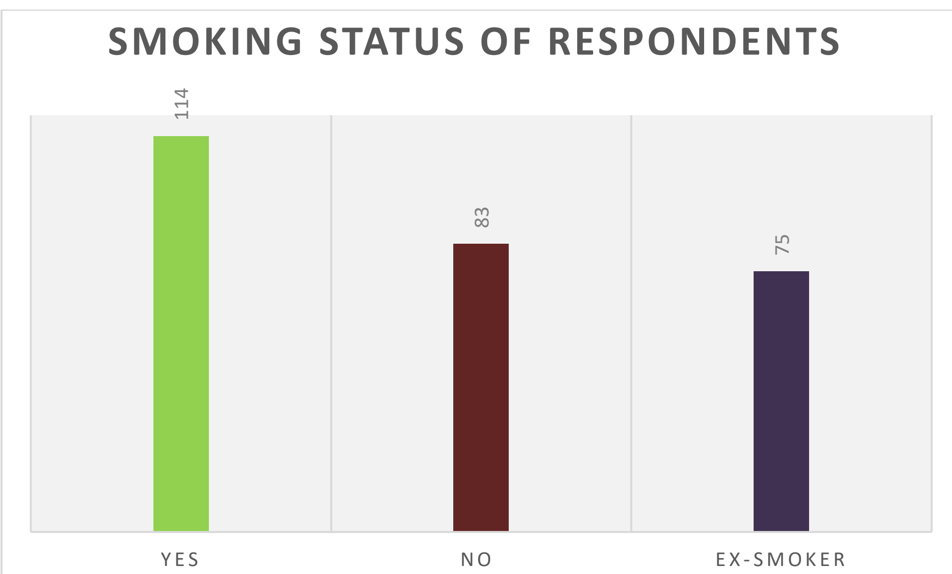
Figure 6.3: Category of respondents:



6.1.4: Smoking Status

According to the respondents' smoking status distribution, smoking is comparatively common in the workforce. A sizable fraction, consisting of 144 persons, currently smoke. Compared to the 75 respondents who are former smokers and the 83 respondents who have never smoked, this group is significantly larger. According to the data, a significant portion of the workforce either never smoked or had stopped, indicating a high incidence of smoking among the workforce.

Figure 6.4: Smoking status of respondents



6.2: Factor Analysis:

Factor Analysis is used as a data reduction technique that permits the reduction of a large number of interrelated variables to a smaller number of latent or hidden dimension. A common usage of factor analysis is in developing objective instruments for measuring constructs which are not directly observable in real life. The most important thing about Factor analysis is it is used when you are working on something and there is no scale available for the particular concept. When we develop our own scale, we have to see whether our scale fits the data or not. To see if these constructs fit in your study we do "**Exploratory Factor Analysis**" and we explore the factor that we want to exist in our data. And if we use the developed scale which have been used earlier by someone, here we use "**Confirmatory Factor Analysis**" to confirm priori established theory.

We performed confirmatory factor analysis (CFA) after exploratory factor analysis (EFA) to verify the validity and reliability of our constructs (Parhyar et, al, 2022).

6.2.1: Exploratory Factor Analysis:

To evaluate the Social Sustainability scale's dimensionality and make sure that every measure included only corresponds with the Social Sustainability dimensions, we ran EFA on 272 samples that were gathered during the first phase (Gorsuch, 1988). Two frequently used decision criteria were applied in order to determine the aspects underlying the Social Sustainability dimension. Initially, items loading with a value of less than 0.5 are not included. Secondly, the items that have more than one cross-loading been not included. According to Henseler et al. (2015), outer loadings alike or bigger than 0.7 are considered to be quite acceptable. According to Chin (1998), a threshold of 0.5 is considered appropriate, and any components with values below this threshold should be disregarded. Table 6.1 list out the outer loadings of factors underlying the social sustainability dimension. The outer loadings for certain items were below from threshold value and all those items were discarded. Based on the aforementioned data (Table 6.4), it is evident that the outer loading value for all other things exceeds 0.7 or higher Additionally, the table indicates that there were no multiple cross loadings for any item, suggesting the scale's preliminary discriminant validity. Lastly, the reliability values of all the factors (Cronbach's alpha) are bigger than 0.70, demonstrating acceptable level of reliability.

Table 6.1: Outcomes from exploratory factor analysis.

		ED	FL	WHS
Equity & Diversity	ED1	**0.703**	0.230	-0.027
	ED3	**0.701**	-0.025	0.316
	ED5	**0.672**	-0.098	-0.071
	ED6	**0.742**	0.291	0.190
	ED7	**0.741**	0.184	0.250
	ED8	**0.729**	-0.016	-0.002
	ED9	**0.755**	-0.027	0.186
	ED10	**0.703**	-0.381	0.460
	ED15	**0.691**	0.234	-0.077
Fair Labor	FL1	-0.723	**0.723**	-0.062
	FL6	-0.74	**0.742**	0.290
	FL7	-0.741	**0.741**	0.350
	FL8	0.321	**0.685**	-0.002
	FL9	0.287	**0.693**	-0.086
	FL13	0.005	**0.702**	-0.033
	FL14	-0.059	**0.729**	-0.071
	FL15	-0.061	**0.714**	-0.041
	FL16	0.324	**0.718**	0.264
	FL18	-0.040	**0.718**	-0.012
	FL19	0.274	**0.669**	-0.023
	FL20	-0.064	**0.737**	-0.016
	FL21	-0.052	**0.683**	-0.063
Worker's health & safety	WHS1	-0.057	-0.073	**0.733**
	WHS2	0.598	-0.034	**0.776**
	WHS3	-0.061	0.215	**0.743**
	WHS4	0.014	-0.018	**0.764**
	WHS5	0.041	-0.060	**0.708**
	WHS6	-0.061	-0.019	**0.714**

	WHS8	-0.064	-0.039	**0.716**
	WHS9	-0.059	-0.062	**0.712**
	WHS10	-0.062	-0.062	**0.805**
	WHS11	-0.066	0.065	**0.760**
Cronbach's Alpha		0.881	0.918	0.910
Eigen Value (Sum of Squares)		4.27	3.37	1.42
Average variance extracted (AVE)		0.512	0.502	0.553

6.2.2 Confirmatory Factor Analysis:

CFA was used to evaluate the scales' uni dimensionality. To evaluate the three SS dimensions, we built a total of two measurement models. In measurement model-1, all social dimensions pertinent to the Social Sustainability dimension were treated as first-order latent variables. First order latent variables like ED, WHS, and FL were used to measure the Social Sustainability dimension, which was regarded as a second order latent construct in the measurement model-2 (Jennings and Carter, 2000). Figure 2 lists the outcomes of each measurement model in terms of the Bentler-Bonett normed fit index (NFI), non-normed fit index, comparative fit index (CFI), adjusted goodness of fit index (AGFI), and goodness of fit index (GFI). According to the results, all of the models show fit indices with a score of 0.90 or higher, which suggests that the two models have acceptable fit indices and that every item is reliable to evaluate the corresponding constructs (Hair et, al, 2010). To improve fit, we kept the measurement items with lower squared multiple correlation values and eliminated the few with the highest standardized residuals values. We also examine the significant justifications for eliminating any measurement items. As a result, our measurement model no longer included the items FL12, FL8, ED5, and ED2, as their item loadings were less than 0.50. We used CR and Cronbach's alpha to test our scales (Fornell and Larcker, 1981). We looked at factor loadings, average variance extracted (AVE), and composite reliability (CR), which shows the standardized path loadings of all the items that are highly closely connected to the equivalent factors, in order to demonstrate convergent validity. High convergent validity is indicated by the fact that all of the model's constructs (Table 6.2) are greater than the AVE and CR threshold levels (Hair et, al, 2010) (more than 0.5 and 0.7, respectively). Make sure the square root of AVE, the average shared variance (AVE), and the maximum shared variance (MSV) are all greater than the inter-construct correlations for the results to be considered valid. in order to demonstrate discriminant validity. The three factor correlations were all less than 0.80, indicating that the scale has discriminant validity. It was discovered that the MSV was smaller than the factors' average shared variance. The average extracted variance (AVE < ASV) is greater than the average shared variance (ASV) standards. Additionally, the values imply that the square root of AVE is larger than the correlations between the constructs. As a result, the discriminant validity test was passed by all six dimensions.

Table 6.2: Convergent and discriminant validity of the constructs.

Construct	**CR**	**AVE**	**MSV**	**ASV**	**WHS**	**ED**	**FL**
Worker’s health & safety	0.925	0.553	0.134	0.056	0.773		
Equity & Diversity	0.904	0.512	0.245	0.145	0.243	0.729	
Fair Labor	0.929	0.502	0.367	0.137	0.465	0.442	0.765

For the three main dimensions examined in the study—Worker's Health & Safety (WHS), Equity & Diversity (ED), and Fair Labour (FL)—the comparison of Average Extracted Variance (AVE) and Average Shared Variance (ASV) shows discriminant validity. The degree to which a concept in a model is actually different from other constructs is known as discriminant validity. The Fornell-Larcker criterion states that a construct is considered to have discriminant validity if its AVE is greater than its ASV, which indicates that it explains more variance in its own observable variables than it does in other constructs. WHS (0.553), ED (0.512), and FL (0.502) all have AVE values in this analysis that are higher than their corresponding ASV values, which are 0.056 for WHS, 0.145 for ED, and 0.137 for FL. These findings unequivocally show that, in comparison to its shared variance with other constructs, each construct maintains a higher degree of internal consistency and convergent validity. This guarantees that, in the context of the cement business, the constructions measure conceptually separate facets of social sustainability. As a result, the observed discriminant validity supports the measurement model's structural soundness and dependability in this investigation.

6.2.2.1: First order confirmatory factor Analysis.

The first order correlated model for SS was created built on the investigation performed with Amos 20 (Kryazos et, al, 2022) (Figure 6.5) According to the first-order model, social sustainability is predicted by three independent dimensions, or constructs: ED, WHS, and FL. There are twelve items measuring the ED construct, ten measuring the WHS construct, and fourteen measuring the FL construct (Fig. 6.5). All necessary tests were successfully completed by the first-order model used to assess social sustainability in the cement industry. Chi-Squared Test: $\chi 2/df$ (CMIN) = 1.481, Goodness of fit index (GFI) = 0.92, non-normed fit index (NFI) = 0.823, Confirmatory fit Index (CFI) = 0.921, and Root Mean Square Error Approximation (RMSEA) = 0.053 (Table 3). As a result, the first order model accurately represents CISS (Seyma et, al, 2022). Additionally, our findings imply that the factor loadings for the first-order ED, WHS, and FL constructs varied from 0.70 to 0.60 to 0.90. Furthermore, there is a.526 correlation between worker health and fair labor, .377 correlation between worker health and equity diversity, and .199 correlation between fair labor and equity diversity.

Figure 6.5: First Order confirmatory factor analysis (Measurement Model)

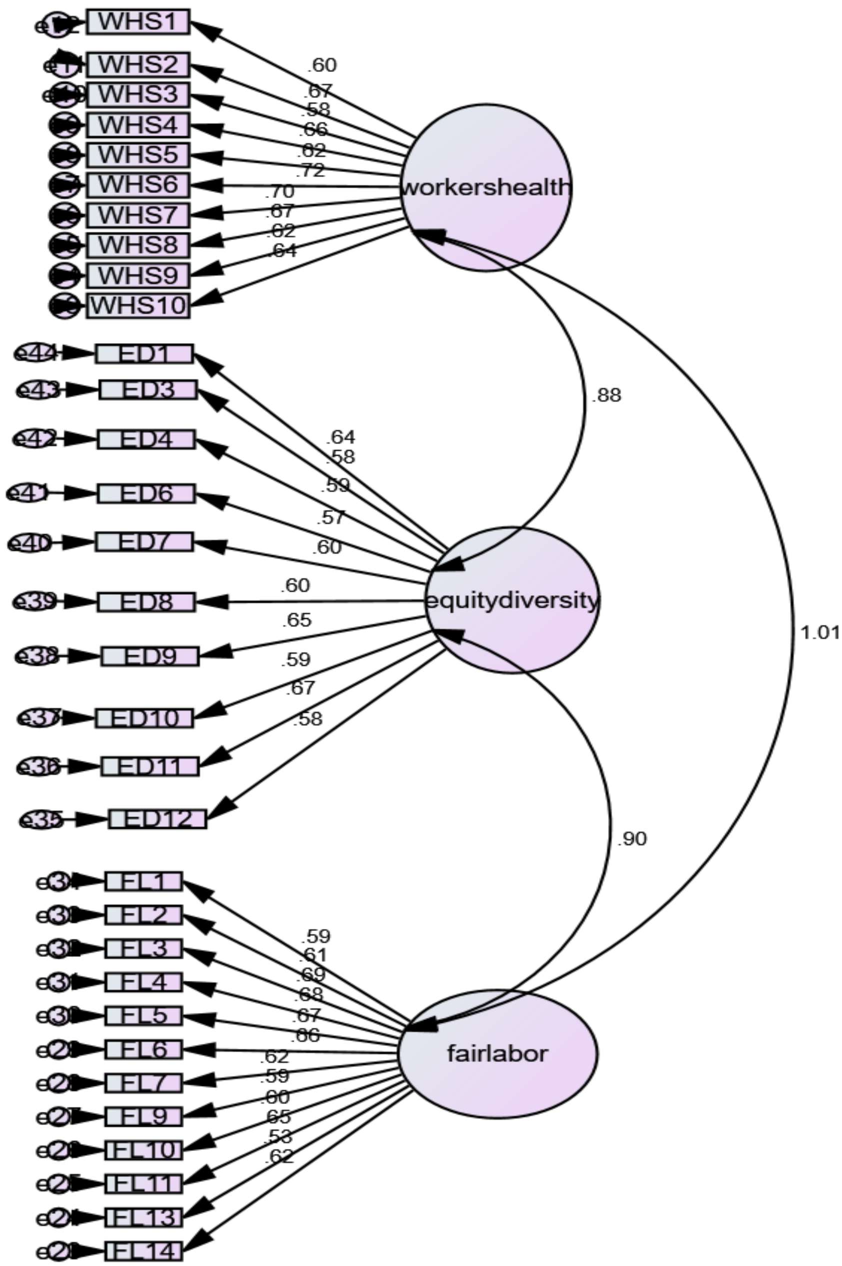


Table 6.3: First order CFA model tests:

Chi Squared test: χ2/df (CMIN)	Goodness of fit index (GFI)	Non-normed fit index (NFI)	Confirmatory fit Index (CFI)	Root Mean Square Error Approximation (RMSEA).
1.481	0.92	0.823	0.921	0.053

Table 6.4: CFA Results for the constructs

Component	Measurement item	Item loading	t statistic	CR	Cronbach's Alpha
Worker's health & Safety	WHS1	0.599	19.951	0.925	0.910
	WHS2	0.674			
	WHS3	0.578			
	WHS4	0.658			
	WHS5	0.618			
	WHS6	0.715			
	WHS7	0.699			
	WHS8	0.667			
	WHS9	0.623			
	WHS10	0.641			
Equity & Diversity	ED1	0.637	19.357	0.904	0.881
	ED3	0.584			
	ED4	0.588			
	ED6	0.567			
	ED7	0.602			
	ED8	0.602			
	ED9	0.648			
	ED10	0.591			
	ED11	0.673			
	ED12	0.583			

Fair Labor	FL1	0.595	38.839	0.929	0.918
	FL2	0.612			
	FL3	0.688			
	FL4	0.678			
	FL5	0.672			
	FL6	0.664			
	FL7	0.619			
	FL9	0.588			
	FL10	0.603			
	FL11	0.646			
	FL13	0.527			
	FL14	0.616			

6.2.2.2: Second order confirmatory factor Analysis

We used Amos 20 for second order CFA in order to test for a second-order model of SocS (Fig. 6.2.2.2). The second-order model proposed a latent factor that controlled the relationships between FL, WHS, and ED. There was a significant path connecting all three of the social dimensions (constructs) to the second order construct (SS). The second order loadings on social sustainability were 0.99 for workers health, 0.90 for equity and diversity and 1.02 for fair labor. Additionally, the SCSS second order model met all goodness of fit requirements. Chi-Squared Test: $\chi2$/df (CMIN) = 1.698, Goodness of fit index (GFI) = 0.956, non-normed fit index (NFI) = 0.882, Confirmatory fit index (CFI) = 0.953, and Root Mean Square Error Approximation (RMSEA) = 0.031 (Table 6.3).

We tested social sustainability's efficacy and predictive validity, which are both covered in more detail in the sections that follow, in order to bolster its importance as a secondary factor. Using the method described by Marsh and However in 1985, we determined the target (T) coefficient, which is the chi-square ratio between the first and second order models, in order to evaluate efficacy. A more effective representation is indicated by a T coefficient greater than 1.0. The model-1 and model-2 chi-square values show that they are the same. Our second order construct effectively clarified the first order construct model, as indicated by a T coefficient that is close to 1.0. As a result, each model offers a clear illustration of how the other works. This outcome also implies that the two models are similar and that the first-order and second-order constructs are exactly the same. The model also reveals that Fair labor have peak path loading (r=1.02) after that workers health & safety (r=0.99) and equity and diversity (r=0.90). According to these findings, the dimensions of social sustainability that are most likely to exist are all three constructs i.e., WHS, ED, and FL.

Figure: 6.6: Second Order CFA Model.

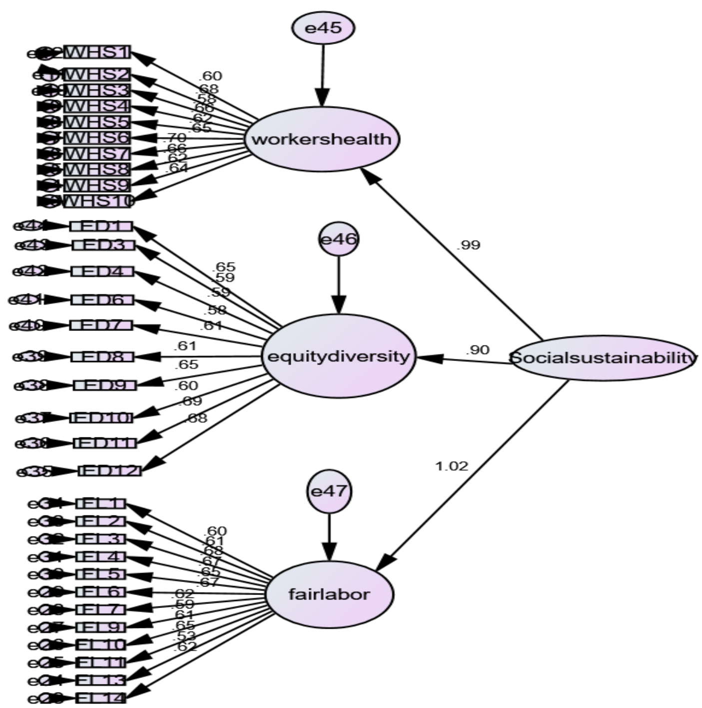


Table 6.5: Second order CFA model tests:

Chi Squared test: χ2/df (CMIN)	Goodness of fit index (GFI)	Non-normed fit index (NFI)	Confirmatory fit Index (CFI)	Root Mean Square Error Approximation (RMSEA).
1.698	0.956	0.882	0.953	0.031

Table 6.6: Factor correlations are used to assess the factors' discriminant validity.

Factor	Mean (SD)	WHS	ED	FL
Workers Health & Safety	2.89	1.000		
Equity & Diversity	3.81	0.286	1.000	
Fair Labor	3.09	0.145	0.235	1.000

Table 6.7: Items on the social Efficiency scale and their corresponding metrics (after refinement) on a 5-point Likert scale (1 being strongly disagree and 5 being strongly agree).

Dimension	Item	Item loading	Measure
Worker's health & Safety	WHS1	0.599	Management and the workforce work together to tackle safety-related issues
	WHS2	0.674	Workplace health and safety is considered extremely important.
	WHS3	0.578	There is an active health and safety committee
	WHS4	0.658	Every one receives compulsory health and safety training.
	WHS5	0.618	Personal protection equipment (PPE) is provided by management.

	WHS6	0.715	Management monitors if PPE is used and worn properly.
	WHS7	0.699	Management Provides health insurance policies
	WHS8	0.667	Safety inspection is done on regular basis.
	WHS9	0.623	Pure drinking water facility at the workplace.
	WHS10	0.641	Availability of clean toilets at the workplace
Equity & Diversity	ED1	0.637	There is diverse environment in this cement plant.
	ED2	##	Management is hiring worker/labor from all communities.
	ED3	0.584	HR and management of the plant are supportive towards disabled people.
	ED4	0.588	Comfortable in discussing social & cultural background with teammates.
	ED5	##	Comfortable in sharing concerns with managers and supervisors.
	ED6	0.567	Rehabilitation packages for displaced workers.
	ED7	0.602	Faced discrimination in workplace due to cultural background.
	ED8	0.602	Management educates the workers regarding equity and diversity.
	ED10	0.648	There are policies and producers to prevent and address discrimination.
	ED11	0.591	Faced retaliation for reporting discrimination from the management.
	ED12	0.673	The management team handles the matters related to equity satisfactorily.
Fair Labor	FL1	0.583	Accommodation facility is provided by the management.
	FL2	0.688	Satisfied with my salary/Wages.

	FL3	0.678	Salary/Wages provided on time.
	FL4	0.672	Receive rewards and recognition for best performance from the owner.
	FL5	0.664	Satisfied with the support from HR department.
	FL6	0.619	Get motivation from the management.
	FL7	0.588	Provident fund facility is provided by management.
	FL8	##	Gratuity is paid at the end of the service
	FL9	0.588	Tripartite relationship between employer, employee and union exists.
	FL10	0.603	Job security exists in the plant.
	FL11	0.646	The management involves in decision making which is relevant to my department.
	FL12	##	work more than 7 hours in a day
	FL13	0.527	Have less working hours in winter.
	FL14	0.616	Have more working hours in summer.

indicates that the factor loading is lesser than cut-off value (0.5).

Table 6.8: Descriptive Statistics:

Variable	**N**	**Mean**	**Standard Deviation**
Workers health & Safety	**272**	**1.73**	**1.18**
Fair Labor	**272**	**3.79**	**1.27**

Equity	**272**	**3.84**	**1.29**
Valid N listwise	**272**		

The table 6.8 displays descriptive statistics for three variables—Workers Health, Equity, and Fair Labor—derived from responses of 299 participants. Each variable was rated on a scale of 1 to 5, with 1 representing "strongly disagree" and 5 representing "strongly agree." For Workers Health, the mean score was approximately 2.74, indicating a tendency towards agreement with statements related to workers' health, with a moderate level of variability reflected in the standard deviation of about 1.19. In contrast, Equity had a notably lower mean score of approximately 1.50, suggesting a strong tendency towards disagreement with equity-related statements, with a standard deviation of about 1.27, indicating a relatively uniform spread of responses around the mean. Similarly, Fair Labor had a mean score of approximately 2.34, indicating a leaning towards disagreement with statements concerning fair labor practices, with a standard deviation of about 1.29, implying some variability in responses.

The analysis of responses from workers in cement plants reveals a nuanced perspective on various aspects of workplace conditions. Regarding workers' health, there's a notable inclination towards recognizing its importance, despite some concerns and room for improvement in specific areas. Conversely, sentiments regarding equity indicate a mixed perception, with both positive aspects and areas requiring attention, particularly in terms of fair distribution of opportunities and addressing discrimination. Concerning overall job satisfaction, the data suggests a moderate level of contentment, though there are areas of dissatisfaction such as salary/wages and support from management and HR. Taken together, these findings emphasize the importance of addressing concerns related to health, equity, and job satisfaction to create a more favourable and equitable work environment within cement plants.

Social Dimension	Study Area (e.g., Kashmir)	India (National Level)	Global Level

Workers' Health & Safety	Moderate awareness; limited PPE use; high exposure to dust and PM	Improved safety policies, yet compliance varies; occupational diseases reported	Strong regulatory standards (e.g., OSHA, EU directives); automation reduces human exposure
Fair Labor Practices	Informal hiring; wage disparities; limited grievance mechanisms	Mix of formal and informal labor; implementation of labor codes underway	Strong unionization; strict adherence to ILO conventions; higher wage transparency
Equity & Diversity	Underrepresentation of women; marginalized communities often in low-tier jobs	Gender diversity improving slowly; affirmative action in public sector	Global push for diversity, equity, and inclusion (DEI); measurable targets in MNCs
Social Security/Benefits	Limited access to insurance, pensions, or health coverage	Government-led schemes exist, but access depends on contract type	Comprehensive social security systems; well-being programs widely adopted
Training & Capacity Building	Mostly on-the-job and limited in scope	Growing focus via CSR and government skill development initiatives	Regular upskilling; integration of tech-based learning platforms

6.4: Discussion:

Social sustainability practices have a significant impact on social efficiency. Specifically, practices related to employee's health & Safety, fair labor & Equity. Study supports assertions made by Fahimeh et, al, (2023). Similarly, our findings align with Ashraf & Naseem (2003); Sana et, al, (2013); who also highlighted that worker have various complaints regarding health issues such as spinal diseases, shortness of breath, fatigue, backpain, and headaches. These complaints are indicative of ergonomic deficiencies in work systems. It emphasizes the improvement in worker health and productivity. Through our investigation of these concepts, we were able to comprehend the intricate connection between the cement industry and social sustainability on a deeper level. The EFA highlighted areas for improvement and illuminated potential interdependencies by revealing underlying patterns and relationships among the items within each construct (khreisat & Mugableh, 2020). The CFA then provided a thorough validation of our suggested model, confirming the dependability and resilience of the chosen indicators (Tarhan et, al 2021). The convergence of the results from the two analyses validates our assessment and highlights the significance of promoting diversity and equity, ensuring fair labor practices, and attending to workers' well-being in order to support the social sustainability of large-scale developments in the cement industry.

Chapter 7

Role of Government policies in sustainability of cement Industry

This chapter assesses how government policies support the sustainability of the cement sector, emphasising the economic, environmental, and social aspects of sustainability. Following a thorough examination of the literature, three policies were chosen to symbolise these aspects: the National Clean Air Programme (environmental sustainability), the Minimum Wage Policy (economic sustainability), and the Occupational Health and Safety laws (social sustainability). In order to set the scene for the investigation, the first section of the chapter provides the demographic profile of the managers employed by cement factories. The managers' opinions on the goals and efficacy of these regulations are examined in the second section, with particular attention to how they affect the cement industry's sustainability.

Table 7.1: An Outline of India's plans for clean air.

Year	**Action**
1974	The Water Pollution Control Act led to the establishment of the Central Pollution Control Board (CPCB).
1981	CPCB assigned the authority and responsibilities under the Air (Pollution Prevention and Control)
1986	CPCB amends the Environmental Protection Act with new provisions.
April 1994	National guidelines for ambient air quality were implemented.
1997	An action plan was created by MoEFCC to reduce pollution in Delhi.
January 1998	In order to address air pollution in the Delhi region of the nation's capital, the Environment Pollution (Prevention & Control) Authority (EPCA) was established.
October 1998	National ambient air quality standards were updated.

2003	The Supreme Court ordered the creation of clean air plans to lower RSPM levels in the following cities: Ahmedabad, Bangalore, Chennai, Hyderabad, Lucknow, Kanpur, Sholapur, and Bangalore.
2009	The Comprehensive Environmental Pollution Index was introduced by CPCB as a tool for industrial cluster environmental assessment.
November 2009	Revisions were made to the national ambient air quality standards, and PM2.5 was added.
January 2014	National Air Quality Index methodology was established.
2015	Under the Air Act of 1981, the CPCB issued directives for the major cities, including Delhi and the National Capital Region (NCR), to implement 42 action points, including control and mitigation measures.
April 2016	All manual stations are covered by the National Ambient Monitoring Programme (NAMP) for PM2.5.
December 2016	In NCR Delhi, a Graded Response Action Plan (GRAP) was created to handle air pollution emergencies.
April 2018	A draft concept notes for the National Clean Air Programme (NCAP) featuring several time-bound tactics to lower air pollution was distributed by the MoEFCC.
July 2018	Under NCAP, 102 non-attainment cities were declared.
October 2018	The states and union territories with non-attainment cities under the NCAP have been directed by the National Green Tribunal (NGT) to prepare an action plan for the reconstituted EPCA, which will include new members from the government, academia, and civil society.

January 2019	MoEFCC introduced NCAP, a time-bound national level strategy to combat rising air pollution. A three-person central committee was established to review and approve clean air plans.
August 2019	20 additional non-attainment cities were added following NGT's intervention
2024	The goal of the NCAP is too lower PM2.5 pollution in 122 non-attainment cities by 20–30% from 2017 levels.

Source: Ganguli et, al, 2020.

Table 7.2: Cities that do not meet the standards of India's National Clean Air Programme

State/ Union Territory	**No. of Cities**	**Cities that have a study on source allocation**
Andhra Pradesh	13	Anantapur, Chitoor, Eluru, Guntur, Kadapa, Kurnool, Nellore, Ongole, Rajahmundry, Srikakulam, Vijayawada, Vishakhapatnam, Vizianagaram
Assam	5	Guwahati, Nagaon, Nalbari, Sibsagar, Silchar
Bihar	3	Gaya, Muzaffarpur, Patna
Chandigarh	1	Chandigarh
Chhattisgarh	3	Bhilai, Korba, Raipur
Delhi	1	Delhi
Gujrat	3	Ahmedabad, Surat, Vadodara
Himachal Pradesh	7	Baddi, Damtal, Kala Amb, Nalagarh, Paonta Sahib, Parwanoo, Sunder Nagar

Jammu and Kashmir	2	Jammu, Srinagar
Jharkhand	1	Dhanbad
Karnataka	4	Bengaluru, Devanagere, Gulburga, Hubli-Dharwad
Madhya Pradesh	6	Bhopal, Dewas, Gwalior, Indore, Sagar, Ujjain
Maharashtra	18	Akola, Amravati, Aurangabad, Badlapur, Chandrapur, Jalgaon, Jalna, Kolhapur, Latur, Mumbai, Nagpur, Nashik, Navi Mumbai, Pune, Sangli, Solapur, Thane, Ulhasnagar
Meghalaya	1	Byrnihat
Nagaland	2	Dimapur, Kohima
Odisha	7	Angul, Balasore, Bhubneshwar, Cuttack, Kalinga Nagar, Rourkela, Talcher
Punjab	9	Amritsar, Dera Bassi, Gobindgarh, Jalandhar, Khanna, Ludhiana, Naya Nangal, Pathankot/Dera Baba, Patiala
Rajasthan	5	Alwar, Jaipur, Jodhpur, Kota, Udaipur
Tamil Nadu	2	Trichy, Tuticorin
Telangana	4	Hyderabad, Nalgonda, Patencheru, Sangareddy
Uttar Pradesh	15	Agra, Allahabad, Anpara, Bareily, Firozabad, Gajraula, Ghaziabad, Jhansi, Kanpur, Khurja, Lucknow, Moradabad, Noida, Raebareli, Varanasi
Uttarakhand	3	Dehradun, Kashipur, Rishikesh
West Bengal	7	Asansol, Barrackpore, Durgapur, Haldia, Howrah, Kolkata, Ranigunj

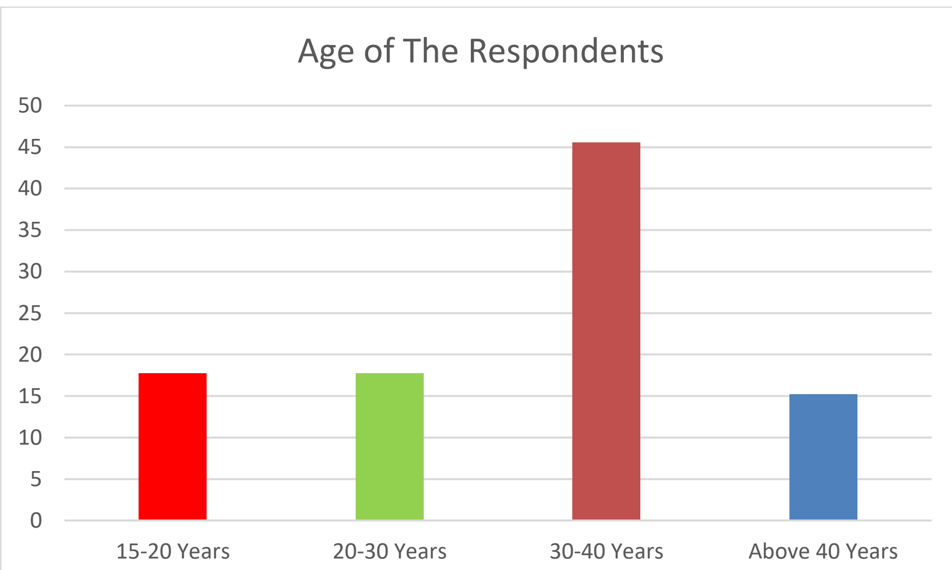
Source: NCAP Report, 2019

7.1: Demographic profile of respondents:

7.1.1: Age

The age distribution of managers employed in cement plants indicates that most of them are between the ages of thirty and forty (Figure 7.1). There are about forty-five of these managers, making this the age group that is most represented. The number of younger managers is less but still fairly balanced, with roughly 15 people in the 15-20 age range and about 20 in the 20-30 age range. There are just about 15 managers who are older than 40 in this smaller group. This shows that there are less young and older managers in the workforce, and that middle-aged professionals make up the majority of managers.

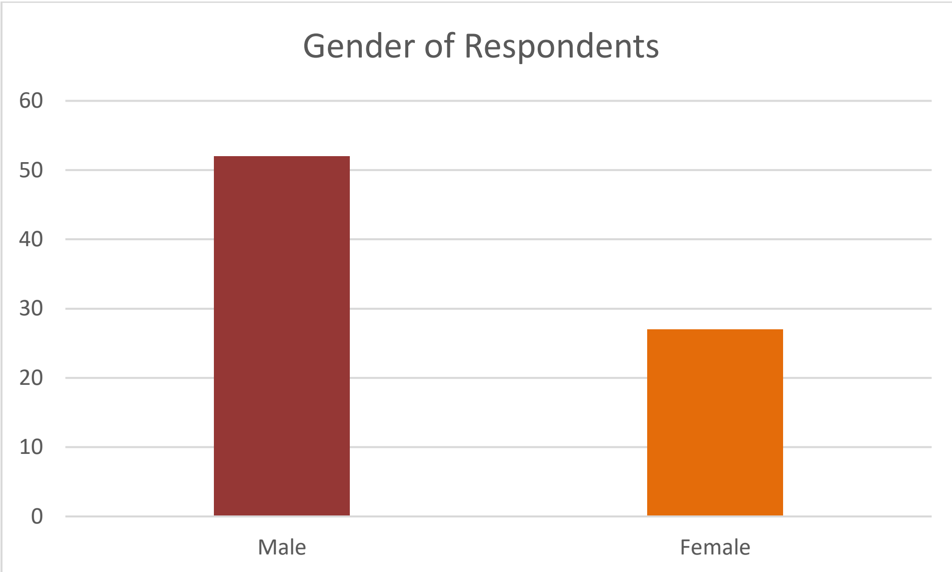
Figure 7.1.: Age distribution of sample



7.1.2: Gender

The gender distribution of the respondents, as shown in the chart, indicates a clear gender imbalance among the participants. Approximately thirty of the respondents are female, which is a smaller group than the fifty or so male respondents who comprise the rest of the sample. Given that men predominate in cement plant management and labour, this suggests that there is a gender gap in this industry.

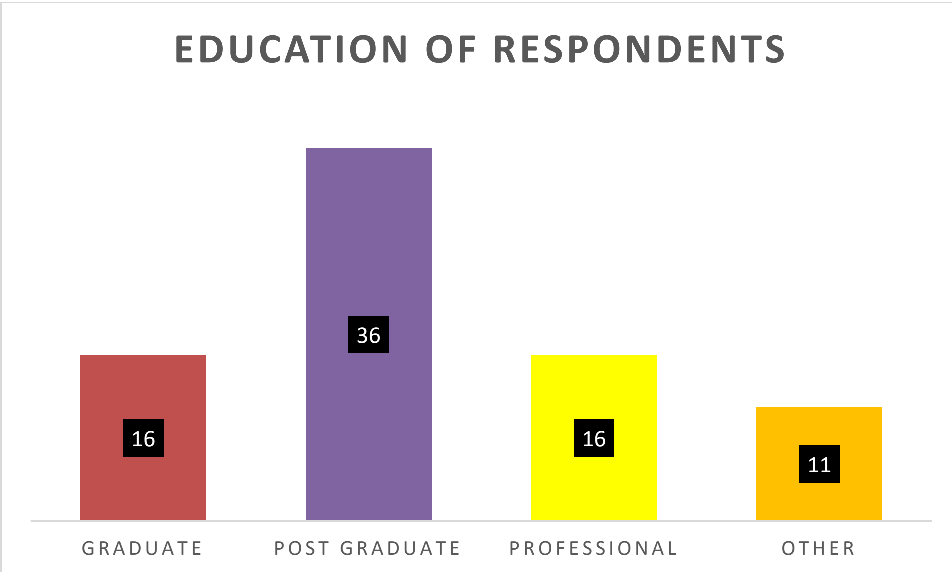
Figure 7.2: Gender of Respondents



7.1.3: Education

Participants' educational backgrounds are diverse, as evidenced by the respondents' distribution of educational backgrounds. Of the 36 persons in the group, the majority have a postgraduate degree, indicating a greater level of academic success. With 16 responders in each category, the graduate and professional categories are equally represented, indicating a balanced representation of these educational levels. With just 11 responses, the "Other" category—which could include diplomas or other types of education—has the fewest responders. Based on this distribution, it appears that most of the respondents have a good education, with a sizable percentage having graduate degrees.

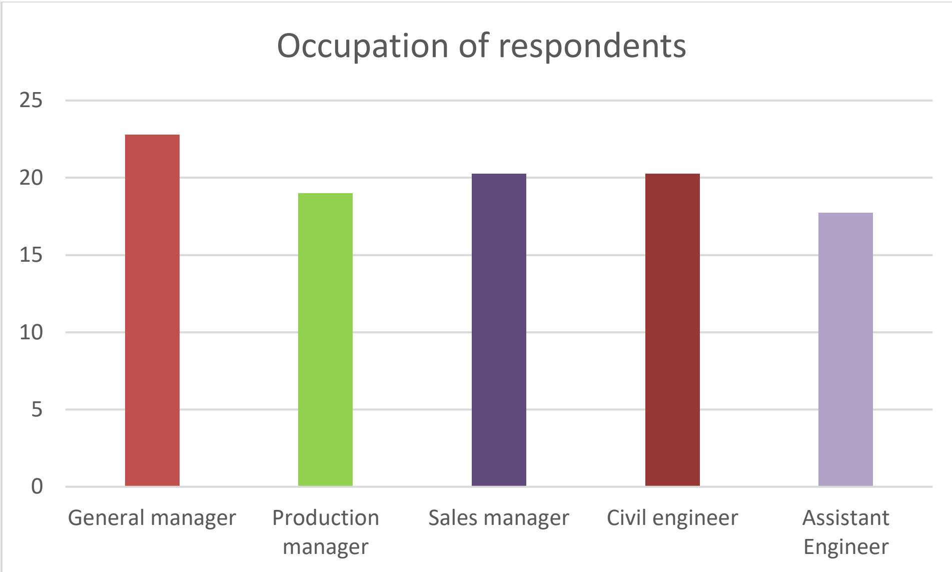
Figure 7.3: Education of respondents:



7.1.4: Occupation

The sample's occupations are dominated by general managers, production managers, and sales managers, who together make up about 20–23% of the total. Assistant engineers and civil engineers make up the remaining significant portion

Figure 7.4: Occupation of Respondents



7.2: validity and reliability:

The technique developed by Casteel & Bridier, 2021was employed to evaluate the validity and reliability of the constructs. Initially, the convergent and discriminant validity of the scale items were assessed, followed by an evaluation of the reliability of the scale items.

Table 7.3: Item loadings, Reliability and Validity.

	Λ	Alpha	CR	AVE	VIF
AP1	0.715	0.881	0.904	0.512	1.832
AP2	0.714				1.825
SW1	0.779				1.545
SW1.1	0.742				1.917
SW1.2	0.734				1.837
SW1.3	0.724				1.708
IP1	0.744				2.283
IP2	0.794				2.026
IP3	0.795				1.605
IP4	0.723	0.918	0.929	0.502	1.856
IP5	0.791				1.856
IP7	0.715				1.845

IP8	0.726				2.374
IP9	0.702				1.899
IP10	0.723				2.204
IP11	0.714				1.978
IP12	0.718				1.916
IP13	0.719				2.226
IP16	0.738				2.091
PI1	0.782				2.123
PI2	0.733	0.910	0.925	0.553	1.967
PI3	0.776				2.234
PI4	0.743				2.084
PI6	0.708				1.766
PI7	0.714				2.038
PI8	0.716				1.948
PI9	0.712				1.837
PI10	0.805				2.684
PI11	0.764				2.274

The convergent validity of the scale items was assessed using three factors. According to [65], it is recommended that factor loadings exceed 0.50 and that the composite reliability of each construct should exceed 0.70. Ultimately, it is imperative that the calculated average variance extracted (AVE) for each construct surpasses the suggested threshold of 0.50 Sekaran & Bougie, 2016. The factor loadings obtained from the analysis of indicators impacting social efficiency demonstrated that the three constructs exhibited convergent validity, as the values surpassed the threshold. The factor loadings of variables that influence social efficiency in this research indicate that the three constructs possess convergent validity, as their values surpass benchmark values across all three dimensions. All factor loadings in the first parameter were found to be more than 0.50. The factor loadings exhibited a range between 0.739 and 0.886. The measures appear to possess convergent validity due to the robust factor loadings. The composite dependability for each construct exceeded a threshold of 0.70. The derived average variance extracted (AVE) for each component exceeded the recommended threshold of 0.50.

7.3: Crosstabulation and Chi Square

7.3.1: Age and Awareness of policies

Data on respondents' awareness of three distinct policies (AP1, AP2, and AP3), broken down by age group, is displayed in the table 7.2. The primary goal of the study is to determine how respondents' ages relate to their knowledge of these policies, specifically the MWP (AP3), OHS (AP2), and NCAP (AP1). The data, which begins with the NCAP (AP1), shows that different age groups have differing awareness levels. The awareness rate for respondents under the age of 20 and 30 is 100%, meaning that every respondent in these age groups is aware of the policy. In contrast, although still relatively high at 92.86% and 91.67%, respectively, awareness decreases slightly for respondents between the ages of 15-20 and over 40. Age and knowledge of the NCAP (AP1) do not appear to be statistically significantly correlated, according to the Pearson Chi2 value of 4.14 and p-value of 0.3877.

Table: 7.4: Cross Tabulation of Age with AP1 (NCAP), AP2 (OHS), AP3 (MWP).

Age	**AP1**			**AP2**			**AP3**		
	Yes	**No**	**Total**	**Yes**	**No**	**Total**	**Yes**	**No**	**Total**
15-20	13	1	14	13	1	14	10	4	14
	92.86	7.14	100.00	92.86	7.14	100.00	71.43	28.57	100.00
	21.67	5.26	17.72	18.06	14.29	17.72	18.52	16.00	17.72
20-30	10	4	14	11	3	14	9	5	14
	71.43	28.57	100.00	78.57	21.43	100.00	64.29	35.71	100.00
	16.67	21.05	17.72	15.28	42.86	17.7	16.67	20.00	17.72

						2			
30-40	26	10	36	35	1	36	24	12	36
	72.22	27.78	100.00	97.22	2.78	100.00	66.67	33.33	100.00
	43.33	52.63	45.57	48.61	14.29	45.57	44.44	48.00	45.57
above 40	8	4	12	11	1	12	9	3	12
	66.67	33.33	100.00	91.67	8.33	100.00	75.00	25.00	100.00
	13.33	21.05	15.19	15.28	14.29	15.19	16.67	12.00	15.19
Total	60	19	79	72	7	79	54	25	79
	75.95	24.05	100.00	91.14	8.86	100.00	68.35	31.65	100.00
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Pearson Chi2 = 4.14 Prob = 0.3877				**Pearson Chi2 = 6.67 Prob = 0.1545**			**Pearson Chi2 = 0.46 Prob = 0.2768**		

Regarding the OHS (AP2), awareness ranges from 91.14% to 100%, with a consistent high level across all age groups. Although it is not statistically significant, the Pearson Chi2 value of 6.67 with a p-value of 0.1545 suggests that there might be a somewhat stronger correlation between age and awareness of this policy when compared to the NCAP. Finally, different age groups have different awareness levels of the Minimum Wage Policy (AP3), with percentages ranging from 68.35% to 100%. The p-value of 0.2768 and the Pearson Chi2 value of 0.46, however, indicate that there is probably significant correlation between awareness of this policy and age. In summary, statistical analysis suggests that age may be a significant factor influencing awareness of these policies, despite fluctuations in awareness levels for each policy across different age groups.

7.3.2: Gender and Awareness of policies:

The relationship between respondents' gender and their knowledge of the NCAP (AP1), OHS (AP2), and MWP (AP3) is depicted in Table 7.3. Beginning with AP1, the percentages of male and female respondents indicate a comparatively high level of awareness (78.55% for males and 70.37% for females). The Pearson Chi2 value of 0.70 with a p-value of 0.4031 indicates that, despite a small difference, there is no significant correlation between gender and knowledge of the National Clean Air Programme.

Table 7.5: Gender and Awareness of policies

Gender	**AP1**			**AP2**			**AP3**		
	Yes	**No**	**Total**	**Yes**	**No**	**Total**	**Yes**	**No**	**Total**
Male	41	11	52	46	6	52	35	17	52
	78.85	21.15	100.00	88.46	11.54	100.00	67.31	32.69	100.00
	68.33	57.89	65.82	63.89	85.71	65.82	64.81	68.00	65.82
Female	19	8	27	26	1	27	19	8	27
	70.37	29.63	100.00	96.30	3.70	100.00	70.37	29.63	100.00
	31.67	42.11	34.18	36.11	14.29	34.18	35.19	32.00	34.18
Total	60	19	79	72	7	79	54	25	79
	75.95	24.05	100.00	91.14	8.86	100.00	68.35	31.65	100.00
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Pearson Chi2 = 0.70 Prob = 0.4031				**Pearson Chi2 =1.35 Prob = 0.2451**			**Pearson Chi2 = 0.08 Prob = 0.7813**		

Regarding AP2, awareness rates are noticeably high for both sexes, with 96.30% of females and 88.46% of males. Once more, a p-value of 0.2451 and a Pearson Chi2 value of 1.35 show that there is no statistically significant correlation between gender and policy awareness regarding occupational health and safety. In conclusion, the percentages of awareness for AP3 are comparable for men (67.31%) and women (70.37%). Gender and awareness of the Minimum Wage Policy do not significantly correlate, as indicated by the Pearson Chi2 value of 0.08 and p-value of 0.7813. In conclusion, there doesn't seem to be a significant correlation between gender and knowledge of the three policies mentioned, according to the data supplied and statistical analysis. Regarding all policies, the respondents—male and female—show comparatively high levels of awareness, with little variation between the two gender groups.

7.3.3: Occupation and Awareness of policies

The information in table 7.4 shows the relationship between respondents' occupation and their knowledge of the NCAP (AP1), OHS (AP2), and MWP (AP3) policies. Examining AP1, awareness levels differ in various professions. The awareness percentages of general managers, production managers, and sales managers are comparatively high, ranging from 77.78% to 100%. The awareness percentages of assistant engineers and civil engineers are lower, ranging from 42.86% to 62.50%. The NCAP and occupation are significantly correlated, as shown by the Pearson Chi2 value of 17.54 and p-value of 0.0015.

Table 7.6: Occupation and Awareness of policy

Occupation	**AP1**			**AP2**			**AP3**		
	Yes	**No**	**Total**	**Yes**	**No**	**Total**	**Yes**	**No**	**Total**
General manager	14	4	18	15	3	18	14	4	18
	77.78	22.22	100.00	83.33	16.67	100.00	77.78	22.22	100.00
	23.33	21.05	22.78	20.83	42.86	22.78	25.93	16.00	22.78
Production manager	15	0	15	14	1	15	9	6	15
	100.00	0.00	100.00	93.33	6.67	100.00	60.00	40.00	100.00

	25.00	0.00	18.99	19.44	14.29	18.99	16.67	24.00	18.99
Sales manager	15	1	16	14	2	16	10	6	16
	93.75	6.25	100.00	87.50	12.50	100.00	62.50	37.50	100.00
	25.00	5.26	20.25	19.44	28.57	20.25	18.52	24.00	20.25
Civil engineer	10	6	16	15	1	16	12	4	16
	62.50	37.50	100.00	93.75	6.25	100.00	75.00	25.00	100.00
	16.67	31.58	20.25	20.83	14.29	20.25	22.22	16.00	20.25
Assistant Engineer	6	8	14	14	0	14	9	5	14
	42.86	57.14	100.00	100.00	0.00	100.00	64.29	35.71	100.00
	10.00	42.11	17.72	19.44	0.00	17.72	16.67	20.00	17.72
Total	60	19	79	72	7	79	54	25	79
	75.95	24.05	100.00	91.14	8.86	100.00	68.35	31.65	100.00
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Pearson Chi2 = 17.54 Prob = 0.0015				**Pearson Chi2 = 3.21 Prob = 0.5239**			**Pearson Chi2 = 1.91 Prob = 0.3523**		

All occupations have generally high levels of AP2 awareness, with percentages ranging from 83.33% to 100%. The OHS policy and occupation do not appear to be significantly correlated, according to the Pearson Chi2 value of 3.21 and p-value of 0.5239. The percentage of workers who are aware of AP3 varies by profession; however, general managers, production managers, and civil engineers have comparatively high awareness rates. The awareness levels of assistant engineers are lower. Nonetheless, a p-value of 0.3523 and a Pearson Chi2 value of 1.91 suggest that there is significant correlation between occupation and knowledge of the MWP.

7.3.4: Awareness of policies and source of awareness

The NCAP (AP1), OHS (AP2), and MWP (AP3) are the three policies that are examined in table 7.5 along with their corresponding associations with information sources (SW1).

According to AP1, 71.15% of respondents who viewed information from the official website exhibited a comparatively high level of awareness. Awareness seems to be influenced by media coverage as well, with a high percentage of 91.30%. The awareness percentages of individuals who rely on professional networks and industry publications, however, are lower at 50.00% and 50.00%, respectively. The p-value of 0.1648 and the Pearson Chi2 value of 5.10 indicate that there might not be a significant correlation between the information source and AP1 awareness.

Table 7.7: Awareness of policies and source of awareness

SW1	**AP1**			**AP2**			**AP3**		
	Yes	**No**	**Total**	**Yes**	**No**	**Total**	**Yes**	**No**	**Total**
Government website	37	15	52	38	4	42	28	11	39
	71.15	28.85	100.00	90.48	9.52	100.00	71.79	28.21	100.00
	61.67	78.95	65.82	52.78	57.14	53.16	51.85	44.00	49.37
Industrial publications	1	1	2	8	2	10	22	11	33
	50.00	50.00	100.00	80.00	20.00	100.00	66.67	33.33	100.00
	1.67	5.26	2.53	11.11	28.57	12.66	40.74	44.00	41.77
Professional networks	1	1	2	1	0	1	0	1	1
	50.00	50.00	100.00	100.00	0.00	100.00	0.00	100.00	100.00
	1.67	5.26	2.53	1.39	0.00	1.27	0.00	4.00	1.27
Media	21	2	23	25	1	26	4	2	6

coverage	91.30	8.70	100.00	96.15	3.85	100.00	66.67	33.33	100.00
	35.00	10.53	29.11	34.72	14.29	32.91	7.41	8.00	7.59
Total	60	19	79	72	7	79	54	25	79
	75.95	24.05	100.00	91.14	8.86	100.00	68.35	31.65	100.00
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Pearson Chi2 = 5.10 Prob =0.1648				**Pearson Chi2 = 2.47 Prob = 0.4814**			**Pearson Chi2 = 2.42 Prob = 0.4890**		

Respondents for AP2 who used the official website to obtain information show a high level of awareness (90.48%), as do those who relied on media coverage (96.15%). Nonetheless, it appears that professional networks and industrial publications have less of an impact; their respective awareness percentages are 100.00% and 80.00%. The p-value of 0.4814 and the Pearson Chi2 value of 2.47 suggest that there is probably no significant correlation between the information source and AP2 awareness. With respect to AP3, respondents who learned about it from official websites and news reports show comparatively high levels of awareness (71.79% and 66.67%, respectively). Again, professional networks and industrial publications have less of an impact on awareness, with percentages of 0.00% and 66.67%, respectively. The p-value of 0.4890 and the Pearson Chi2 value of 2.42 indicate that there might not be a significant correlation between knowledge of AP3 and the information source.

In conclusion, the statistical analysis indicates that there may not be a significant correlation between the information source and policy awareness, despite differences in awareness levels across various information sources for each policy. On the other hand, it seems that some sources—such as official websites and media coverage—have a comparatively greater influence on awareness than others.

According to the information given, occupation and the NCAP (AP1) have a significant correlation (Pearson Chi2 = 17.54, Prob = 0.0015), but not with other demographic factors. There is no statistically significant correlation found between any demographic factor and AP2 (MWP). There is no statistically significant correlation found between any demographic factor and AP3 (OHS).

The aforementioned results unequivocally support our null hypothesis, which stated that there is no meaningful correlation between demographic characteristics and the degree of knowledge about occupational health and safety, minimum wage laws, and the NCAP. Here, our null hypothesis has been accepted because the data unequivocally demonstrates that there is no correlation between demographic characteristics and policy awareness levels.

7.4 Regression

7.4.1 Socio economic index and policy Impact

Using two distinct measures—NCAP_Index and NCAPGM—the regression analysis looked at the relationship between the socioeconomic index (SEI) and the effects of the NCAP (Table 7.6). A statistically significant coefficient of 0.398 was found for the model that used NCAP_Index, indicating that SEI tends to increase by about 0.398 units for every unit increase in NCAP_Index. This result suggests a real relationship between socioeconomic status and the NCAP's effects. The constant term, however, did not show statistical significance, suggesting that SEI is not always equal to the constant term when NCAP_Index is zero. Similarly, the coefficient of 0.165 in the model with NCAPGM was statistically significant and showed that SEI tends to increase by about 0.165 units for every unit increase in NCAPGM. This demonstrates yet another important connection between socioeconomic status and a particular NCAP impact measure. The constant term was not statistically significant, just like in the prior model.

Table 7.8: SEI and Policy Impact (NCAP)

Variable	Obs	Mean	Std.Dev.	Min	Max
SEI	79	2.570	0.674	1	3.670
SEIGM	79	7.709	2.020	3	11
NCAP_Index	79	4.234	0.390	2.880	5

NCAPGM	78	33.897	3.107	23	40

Linear regression

SEI	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
NCAP_Index	.398	.192	2.07	.041	.016	.78	**
Constant	.886	.815	1.09	.28	-.737	2.51	
Mean dependent var	2.570	SD dependent var	0.674				
R-squared	0.053	Number of obs	79				
F-test	4.299	Prob > F	0.041				
Akaike crit. (AIC)	160.535	Bayesian crit. (BIC)	165.274				
**** p<.01, ** p<.05, * p<.1*							

SEIGM	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
NCAPGM	.165	.072	2.29	.025	.021	.308	**
Constant	2.095	2.451	0.85	.395	-2.786	6.976	
Mean dependent var	7.679	SD dependent var	2.016				
R-squared	0.064	Number of obs	78				
F-test	5.235	Prob > F	0.025				
Akaike crit. (AIC)	328.536	Bayesian crit. (BIC)	333.249				
**** p<.01, ** p<.05, * p<.1*							

The statistically significant F-tests for both models showed that they are significant overall. The R-squared values, however, were rather low, indicating that the variation in NCAP impact only accounts for a minor fraction of the variance in the socio-economic index. This suggests that although NCAP_Index and NCAPGM are linked to socioeconomic status, SEI is probably influenced by a number of other factors in addition to the National Clean Air Programme's effects.

The purpose of the regression analysis was to investigate the relationship between the socioeconomic index (SEI) and the effects of the OHS policy, as measured by the OHS GM and OHS Index (Table 7.7). The coefficient of 0.188 with a standard error of 0.115 was estimated in the first model that used OHS Index. It is possible that the relationship between OHS Index and SEI is not statistically significant because this coefficient (p = 0.106) did not reach statistical significance at the traditional 0.05 level. Similarly, a coefficient of 0.134 with a standard error of 0.094 was obtained from the second model that used OHS GM. Once more, the coefficient failed to show statistical significance (p = 0.156), suggesting that there is insufficient data to support a link between OHS GM and SEI.

Table 7.9: SEI and Policy Impact (OHS)

Variable	Obs.	Mean	Std. Dev.
SEI	79	2.570	0.674
SEIGM	79	7.709	2.020
OHS_Index	79	5.225	0.658
OHS GM	79	16.671	2.422

Linear Regression

SEI	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
OHS_index	.188	.115	1.64	.106	-.041	.416	
Constant	1.589	.605	2.63	.01	.385	2.792	**

Mean dependent var	2.570	SD dependent var	0.674
R-squared	0.034	Number of obs	79
F-test	2.675	Prob > F	0.106
Akaike crit. (AIC)	162.129	Bayesian crit. (BIC)	166.868

*** *p<.01, *** *p<.05, ** *p<.1*

Linear regression

SEIGM	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
OHS GM	.134	.094	1.43	.156	-.053	.321	
Constant	5.47	1.58	3.46	.001	2.323	8.617	***

Mean dependent var	7.709	SD dependent var	2.020
R-squared	0.026	Number of obs	79
F-test	2.049	Prob > F	0.156
Akaike crit. (AIC)	336.209	Bayesian crit. (BIC)	340.948
**** p<.01, ** p<.05, * p<.1*			

The constant term in both models was statistically significant, meaning that the estimated SEI for the OHS_Index and OHS GM models is expected to be 1.589 and 5.47, respectively, when the impact of the occupational health and safety policy is zero. The low R-squared values of both models, however, indicate that the variation in OHS policy impact can only account for a minor fraction of the SEI variance. The models may not fully capture the relationship between the impact of OHS policies and socioeconomic status as determined by SEI if the F-tests for the models' overall significance were not statistically significant.

To summarise, the results of the regression analysis indicate that there is no significant correlation between the socio-economic index (SEI) and either the OHS GM variable or the OHS_Index. This suggests that, at least according to the SEI variable used in this analysis, the impact of the Occupational Health and Safety policy may not be highly correlated with socioeconomic status.

Regression analysis was used to investigate the relationship between the socioeconomic index (SEI) and the MWP impact, as measured by the MWP GM and MWP_Index (Table 7.8). The coefficient of 0.165 with a standard error of 0.137 was estimated in the first model that used MWP_Index. Nevertheless, this coefficient (p = 0.233) did not achieve statistical significance at the traditional 0.05 level, indicating a weak case against a relationship between MWP_Index and SEI. Similarly, a coefficient of 0.026 with a standard error of 0.022 was obtained from the second model using MWP GM; this coefficient was not statistically significant (p = 0.236).

The estimated SEI is predicted to be 1.911 and 5.747, respectively, for the MWP_Index and MWP GM models when the impact of the Minimum Wage Policy is zero, according to the statistically significant constant term in both models. But the R-squared values for both models were low, meaning that the variation in the Minimum Wage Policy's impact can only account for a small fraction of the variance in SEI. Moreover, the statistical insignificance of the F-tests for the models' overall significance suggests that the models might not fully represent the correlation between the impact of MWP and socio-economic status as determined by SEI.

Table 7.10: SEI and Policy Impact (MWP)

Variable	**Obs.**	**Mean**	**Std. Dev.**
SEI	79	2.570	0.674
SEIGM	79	7.709	2.020
MWP_ Index	79	3.983	0.554
MWP GM	79	75.684	10.519

Linear regression

SEI	Coef.	St. Err.	t-value	p-value	[95% Conf	Interval]	Sig
MWP_Index	.165	.137	1.20	.233	-.108	.439	
Constant	1.911	.553	3.46	.001	.811	3.012	***

Mean dependent var	2.570	SD dependent var	0.674
R-squared	0.018	Number of obs	79
F-test	1.446	Prob > F	0.233
Akaike crit. (AIC)	163.358	Bayesian crit. (BIC)	168.096

**** p<.01, ** p<.05, * p<.1*

Linear regression

SEIGM	Coef.	St. Err.	t-value	p-value	[95% Conf	Interval]	Sig
MWP GM	.026	.022	1.20	.236	-.017	.069	
Constant	5.747	1.657	3.47	.001	2.448	9.046	***

Mean dependent var	7.709	SD dependent var	2.020
R-squared	0.018	Number of obs.	79
F-test	1.429	Prob > F	0.236
Akaike crit. (AIC)	336.831	Bayesian crit. (BIC)	341.570

*** p<.01, ** p<.05, * p<.1

To summarise, the results of the regression analysis indicate that there is no significant correlation between the socio-economic index (SEI) and either the MWP GM variable or the MWP_Index. This suggests that, at least based on the SEI variable used in this analysis, the impact of the Minimum Wage Policy may not be highly correlated with socioeconomic status.

We would accept the Null Hypothesis (H0) (O2) since the regression coefficients were not statistically significant. This indicates that there is not enough data, according to the analysis done, to imply that people's perceptions of the efficacy of policies are highly influenced by their socioeconomic status.

7.5 Discussion:

According to the results, policy awareness and age have a positive link that peaks in the 36–45 age range. According to this tendency, middle-aged workers know more about workplace regulations than do their younger and older counterparts.

According to Smith et, al, 202, workers in the middle-aged range (35–50) have a larger awareness of workplace policies since they participate in training more frequently and have more experience. The conclusion that middle-aged workers are the most policy-aware group is supported by this study. According to Jones Jones, 2019 workers with longer service histories—typically those between the ages of 36 and 55—have higher policy compliance because they are more involved in the formulation and application of policies. This is consistent with the finding of the present study that these age groups exhibit high awareness. Williams and Brown William & Brown, 2021 observed that fewer employees (those over 55) are aware of new policies and training because they find it difficult to stay current. The oldest age group shows a comparable drop in policy awareness, according to the current study.

The National Clean Air Programme appears to have a favourable correlation with socioeconomic status, as indicated by the statistically significant association between SEI and the NCAP models (both NCAP_Index and NCAPGM). However, only a small percentage of the variation in SEI can be explained by this link. Relationships between SEI and the OHS and MWP models are not statistically significant. This implies that the effects of minimum wage and occupational health and safety laws may not be highly connected with socioeconomic level. The substantial correlation between SEI and NCAP impact metrics is in line with research highlighting the unequal impacts of environmental regulations on various socioeconomic strata. Smith et al.

(2020), for example, discovered that improvements in air quality brought about by environmental rules frequently benefit higher socioeconomic groups more, most likely as a result of improved access to resources and information. The lack of substantial correlation between OHS policies and SEI is consistent with the findings of Jones (2019), which hypothesized that because rules are implemented uniformly across socioeconomic strata, advances in occupational health and safety frequently do not greatly correspond with socioeconomic status. However, depending on the sector and particular governmental initiatives, this can differ greatly. While some research, such as Williams and Brown (2021), found that minimum wage rules tend to have more obvious effects on lower socioeconomic groups, the non-significant results for MWP impact measures and SEI are in contrast. The cement industry's unique circumstances, where salaries may already be over minimum wage limits, or other mitigating factors like union agreements and industry regulations could be the cause of this disparity.

Chapter 8

Conclusion, Suggestions, and Implication

The foundation of many infrastructure projects, including buildings, bridges, roads, and dams, is provided by the cement industry, which is essential to the advancement of the economy. The demand for cement is expected to rise further as the world's population becomes more urbanised, especially in developing nations where urbanisation and rapid industrialisation are common. China is the world's top producer of cement, accounting for more than 50% of the world market. Other major producers include the US, Turkey, Vietnam, India, and the United States. The cement industry contributes significantly to world CO_2 emissions, making up about 7–8% of total emissions, despite its significance to the global economy. Calcinating limestone releases a significant amount of carbon dioxide during the highly energy-intensive production process. Consequently, there is increasing pressure on the industry to lower its carbon footprint. Innovations in industrial methods have resulted from this, including the creation of substitute materials, carbon capture systems, and the use of renewable energy sources. Global regulatory agencies are also enforcing more stringent environmental laws, which is driving the sector towards more environmentally friendly operations.

Another important part of the cement industry is international trade, where big producers export to areas with strong demand but little capacity for production. Local production is typically more economically feasible, but trade is frequently restricted by the high cost of transportation in comparison to the value of the product. In order to maximise production efficiency, cut waste, and save costs, the industry is progressively implementing digital technologies, such as Industry 4.0 solutions, in response to these difficulties. These developments are anticipated to have a significant impact on how the cement industry develops in the future by striking a balance between the necessity of sustainability and continuous growth. Trade policies, geopolitics, and shifting global economic conditions all have an impact on the cement business. Economic downturns, as those brought on by pandemics or financial crises, can result in less building activity, which has an immediate effect on the demand for cement. On the other hand, the industry can benefit from government stimulus plans that prioritise infrastructure construction. Trade conflicts and sanctions are examples of geopolitical issues that can impact the movement of raw materials and finished goods, changing the competitive environment. Furthermore, the industry's dependence on natural resources—such as gasoline, limestone, and clay—exposes it to commodities market volatility, which affects profitability and production costs.

Furthermore, the sector is coming to understand the significance of CSR (corporate social responsibility) and the necessity of addressing the environmental and social effects of its activities. Businesses are making investments in supply chain sustainability, labour condition improvement, and community development. With initiatives to recycle waste materials into cement manufacturing and lessen the industry's overall environmental imprint, the shift towards a circular economy is also gaining steam. These patterns point to a change in the direction of more ethical business practices as stakeholders expect cement producers to be more accountable and transparent. The industry's long-term success will depend on how well it manages growth, sustainability, and social responsibility as it changes.

8.1: Rationale of the study:

In terms of manufacturing capacity, the Indian cement industry is among the biggest in the world, coming in second only to China. It is essential to the nation's economic progress, especially in the infrastructure and building industries, which are major forces behind India's expansion. The industry has a considerable economic influence, as seen by its 7-8% GDP contribution to India. The widespread use of cement in important infrastructure projects, including roads, bridges, dams, and urban development, supports this contribution. Cement is predicted to be in high demand due to ongoing government efforts including the "Smart Cities Mission," "Housing for All," and the "Bharatmala" project, which further increases cement's economic significance.

The cement business employs a significant number of workers, directly and indirectly supporting over a million people. While indirect employment involves related industries including logistics, construction, and retail, direct employment includes positions in cement manufacturing plants, distribution, and sales. Because of the labour-intensive character of the sector, notably in its manufacturing and distribution processes, it is an essential source of employment in rural areas, especially in the areas where cement plants are located. Cement facilities are widely dispersed geographically throughout India, which boosts regional development and local economies. Future growth of the Indian cement industry is anticipated due to continuous urbanisation and infrastructural development. The sector does, however, confront difficulties, such as the supply of raw materials, environmental issues, and shifting energy prices. Innovation, environmentally friendly methods, and effective resource management will be essential in addressing these problems if the sector is to continue making a major job and GDP contribution to India. Future success in the industry will be greatly influenced by its ability to adapt and its dedication to sustainability.

Despite being smaller than in other parts of India, Kashmir's cement sector is extremely important to the local economy. The growing demand from home developments and infrastructure projects has propelled the region's cement industry's steady growth throughout the years. The growth of Kashmir's cement industry has also been impacted by its distinct geographical and political circumstances, making it both important and difficult. The Kashmir Valley is home to most of the country's small- to medium-sized cement factories, which supply the region's needs. The industry supports other adjacent sectors including construction and transportation and adds significantly to the region's economy by creating jobs. Because of Kashmir's rugged terrain and sporadic connectivity outages, it is logistically difficult to transport cement from other regions of India, which makes local cement manufacturing crucial to addressing the region's infrastructural needs. Government infrastructure projects, such as public buildings, roads, and bridges, as well as private construction projects, such as residential and commercial developments, are the main sources of demand for cement in Kashmir. Because of the tough weather in the area—which includes frigid winters and a lot of snow—the local business works hard to produce cement that is both high-quality and long-lasting. However, the industry faces a number of difficulties, such as high production costs brought on by the importation of energy and raw materials, a restricted capacity for growth, and the effect of political unrest on corporate operations. Government infrastructure projects, such as public buildings, roads, and bridges, as well as private construction projects, such as residential and commercial developments, are the main sources of demand for cement in Kashmir. Because of the tough weather in the area—which includes frigid winters and a lot of snow—the local business works hard to produce cement that is both high-quality and long-lasting. However, the industry faces a number of difficulties, such as high production costs brought on by the importation of energy and raw materials, a restricted capacity for growth, and the effect of political unrest on corporate operations.

Numerous studies are available on the environmental aspects of cement industry but there is dearth of systematic and empirical analysis of economic and social aspects of cement industry in Kashmir. Thus, the main aim of the present study is to examine socio- economic and environmental implications of cement industry on workers and society in Kashmir.

The objectives of the present study are as follows:

1. To assess the economic efficiency of cement industry in Kashmir.
2. To analyze the impact of cement industry on the environment in Kashmir.
3. To evaluate the social efficiency of cement industry in Kashmir.
4. To evaluate the role of government policies in the sustainability of cement industry in Kashmir

8.2: Economic Efficiency of cement industry

This paper therefore offers a productive, efficient and operational look at nine cement plants in the region of Kashmir. The productivity changes and trends of these firms between the years 2021 and 2023 have been elicited using Malmquist Productivity Index in conjunction with DEA analysis, overall, the industry saw a very modest productivity growth rate of 4.1% in the given time period; however, this was coupled with significant fluctuations in rates for individual plants. Khyber Cement emerged superior to other companies exhibiting a total factor productivity growth rate of 74 percent, barring any error, overhauls by innovation and steady unbroken managerial performance. Some companies like the Valley Cement and TCI recorded decreased productivity where TCI saw it decrease by 18.4% mainly due to scale and technology. DEA outcome indicates that the business of Khyber LMT and Valley Cement possessed constant efficient resource management and output capacity during the analysis period. Nonetheless, productivity decreased in firms like TCI and Arco Cement, which showed organisational problems in magnifying its performance. Firms such as TCI MAX, Saifco Cement and Cemtac Cement showed increased productivity overtime as a result of management and achievement of scale economies. Comparing with the peers benchmark it was noted that many firms including Valley cement and Cemtac cement are considered as benchmarks for many other firms which indicates about the sound operation of such firms.

The report highlights the importance of technological advancement and scale operation to transform productivity improvement in cement industry. Companies that were sluggish in these processes suffered to manage on efficiency front, while the others like Khyber Cement benefited due to innovation and optimized scale factor. According to the analysis, new technologies and tools for scale management to stay efficient are the key factors for cement industry productivity. The differential outcomes obtained by firms underscore the importance of addressing such issues in a manner that is firm specific, focus areas such as technology adoption and utilization of resources. The conclusion of these analyses is informative of industrial and policy recommendations that will assist those in the management of the cement industry and policy formulation in the state of Kashmir to deliver the improved sustainability efficiency of the sector.

8.3: Impact of cement industry on environment:

A complicated interplay between industrial operations and local environmental circumstances is revealed by the environmental impact of the cement industry in Kashmir's Khrew and Khanmoh areas from 2014 to 2023. The examination of trends in air quality, specifically PM10 levels, shows fluctuation devoid of a distinct linear pattern, with notable peaks in 2016 and 2020. These variations could be attributed to variations in the weather and industrial activities. A significant decrease in PM10 concentrations in 2019 raises the possibility of the effectiveness of concerted mitigation efforts, while later years reveal erratic trends, highlighting the necessity of focused study to pinpoint precise pollution sources. Variations in seasonal air quality emphasise even more how closely pollution levels and weather patterns are related. Khanmoh's pollution levels peak in the summer, with the monsoons providing some respite, while Khrew sees the worst air quality throughout the winter, with some relief during the monsoon season. These results imply that region-specific mitigation techniques are necessary, accounting for both local seasonal fluctuations and industrial emissions. Furthermore, the Khrew area's health statistics highlights the influence of the environment on public health, highlighting the increasing occurrence of respiratory ailments such acute bronchitis and bronchial asthma. Even though there is a minor rising trend in chronic bronchitis, there is an urgent need for focused health interventions due to the changing incidence of skin infections, the worrisome reduction in lung function, and irregular pulse rates.

In conclusion, in order to preserve environmental sustainability and public health for future generations, tackling the environmental impact of the cement industry in Kashmir necessitates a comprehensive strategy that includes data-driven analysis, region-specific mitigation strategies, and stakeholder collaboration.

8.4: Social efficiency of Cement industry:

An intricate and multi-layered picture of working conditions is provided by the examination of the comments given by employees in Kashmiri cement facilities. There is broad recognition of the importance of worker health and safety, and many employees are aware of the measures taken to protect their wellbeing. Even while there has been progress, there is still need for development in areas like occupational safety, access to healthcare facilities, and protective measures, as the data also raises some concerns. Regarding equitable labour practices and fair labour practices, different workers have different opinions. While some employees believe that progress is being made in guaranteeing equality and justice, especially with regard to treating co-workers with respect and in a fair manner, there are still observable areas that require improvement.

Crucial topics that need to be addressed include things like fair opportunity distribution, openness in promotions and rewards, and dealing with bias and discrimination. In terms of overall job satisfaction, the results indicate that employees are rather satisfied with their positions. There are major areas of dissatisfaction, even while other components of the job are valued, such the relationships with co-workers and the sense of stability. Employees voiced concerns about their pay and benefits, saying that they did not adequately compensate them for the danger and effort they took on in their jobs. Workers have expressed concerns over the level of support they receive from management and HR, emphasising the need for improved communication, more supportive work environments, and more consistent and equitable management methods. These revelations highlight how critical it is to solve issues with fairness, health, and job happiness in Kashmiri cement plants. By concentrating on these crucial areas, it is possible to improve the industry's overall social efficiency and make the workplace more welcoming, encouraging, and equal for all employees.

8.5: Role of government policies in sustainability of cement industry

This study's thorough analysis sought to understand the complex interactions between a range of organizational, socioeconomic, and demographic characteristics and the adoption of important regulations in the cement sector. Many insights were obtained by means of regression analyses that looked at variables like age, gender, occupation, socioeconomic index, and presence of plants in addition to policy indices like the Minimum Wage Policy (MWP), Occupational Health and Safety (OHS), and National Clean Air Programme (NCAP). Many of the factors did not reach statistical significance, even though some showed associations with adherence to policy implementation. Notably, for all of the policies under study, the presence of plants had no discernible effect on policy adherence. All things considered, the study emphasises how difficult it is for the cement industry to implement policies and how varied the variables affecting compliance are.

A number of recommendations are made in light of the findings to improve policy implementation and regulatory compliance in the cement industry. Regulatory bodies ought to persist in their oversight and implementation of extant protocols, including NCAP, OHS, and MWP, to guarantee ecological sustainability, occupational safety, and equitable labor standards throughout all cement manufacturing facilities. The awareness gap could be closed by implementing policy education-focused onboarding workshops and regular refresher courses. The fall in awareness can be lessened by providing regular updates, customized training sessions to reflect new rules and regulatory changes, and interesting techniques to keep participants' attention and involvement. Furthermore, it is imperative to cultivate cooperation among regulatory agencies, industry participants, and pertinent associations in order to share optimal methodologies and advance ongoing enhancements in policy compliance and ecological responsibility in the sector.

The results point to the necessity of focused actions to guarantee that the advantages of environmental policies such as NCAP are dispersed fairly among all socioeconomic classes. Enhancing communication and training methods for OHS policies could increase their efficacy for all socioeconomic categories. To make sure minimum wage laws accomplish the desired socioeconomic advantages, their effects may need to be revaluated in certain industry contexts. In order to develop targeted interventions and strategies for improving policy implementation and sustainability, future research endeavors should investigate additional factors influencing policy implementation within the cement industry, such as organizational culture, management practices, and external market dynamics. The cement industry can strive towards attaining elevated levels of regulatory compliance and environmental responsibility, as well as promoting long-term sustainability, by embracing a comprehensive approach that takes into account multiple factors that impact policy adherence.

8.6: Conclusion of study:

This study gives a detailed assessment and analysis of the cement manufacturing industry in the Kashmir region, in terms of its economic impacts, environmental concerns and social issues, as well as the regulations affecting it. It captures the issues and prospects that characterise the industry and provides a framework on the optimisation and resilience of the industry.

Analysing nine cement plants, the assessment of the economic situation gives a picture of the development of productivity in the sector for 2021-2023. While the overall industry only had a 4.1% annual growth rate, there were large differences between various specific firms. Albeit some firms: for instance, Khyber Cement, boosted technological advancement and Pragmatic managerial policies following which they have recorded a fabulous 74 % productivity improvement. On the other hand, most enterprises such as TCI and Valley Cement experienced a negative trend in productivity mainly because of scale diseconomies and technology lock-ins. They provide strong evidence for the proposition that sustained innovation, efficient resource utilisation and scale are paramount as industry players strive to retain competitiveness and efficiency in the industry.

The environmental effects have been observed concerning the cement industry in the Kashmir area nonetheless the cement sectors in both Khrew and Khanmoh regions have emitted environmental air quality for many years. Moderate changes in the figures were detected with relatively better pollution control measures in 2019 with oscillatory variations observed in the three years 2016,2019 and 2020. Other factors peculiar to the location likewise had surfaced – enhanced pollution during summer and winter depending on the place. The dire consequences on health, for instance, increased incidences of respiratory ailments like bronchitis and asthma, compel the argument for a targeted green approach to the region. These issues can be well solved not only by enhancing the related technologies but also by improving the cooperation among industries, regulatory bodies and local communities.

From a social perspective, the study offers important knowledge on working conditions in cement factories in Kashmir. Despite some level of improvement in worker health and safety there are issues that have raised concerns such as lack of standard in occupational safety dimension, and unfair treatment of workers. Employees complained loud and clear about remuneration and recognized the fact that they are not compensated fairly for the risks they take. Problems of promotion, biased, and discriminations were also raised, which showed inefficiency in management practices and requirement of friendly work atmosphere to embrace all. Improve system cooperation in the industry is important for creating a better and happier staff, which leads to greater organizational effectiveness. Government policies thus play a significant role determining sustainability and compliance issues affecting the cement industry. Hypotheses tested included the level of compliance with the Minimum Wage Policy (MWP), Occupational Health and Safety (OHS), and the National Clean Air Programme (NCAP). However, several related socioeconomic factors remained inconsequential in defining the level of policy compliance and the presence of cement plants did not guarantee superior levels of compliance. This brings out the need for more stringent regulatory measures, policy awareness and cross-sectional policy enforcement measures. Training sessions, updated communication and awareness tools together with mutual cooperation between the regulators and the industries can lead to enhanced standard and compliance, occupational health and safety and environmental stewardship.

Therefore, it is pointed out in this study that the cement manufacturing sector in the context of Kashmir is laden with specific issues socio-economic and others having to do with the environment and the society. Solving these problems is possible only through using technological solutions, protecting the environment and increasing employment rates, including the use of reasonable measures by the government. In this way the industry will be able to increase its productivity and thus its competiveness while at the same time maintain sustainability and a high level of social responsibility. From this study, relevant recommendations can be made to policymakers, industry stakeholders and other relevant decision makers to enhance the industry for the benefit of all those involved and in the region.

8.7: Suggestions

- **Promote Technological Innovation:** According to the report, companies like Khyber Cement that made substantial technological breakthroughs saw notable increases in output. To encourage cement factories to adopt innovations that improve technical efficiency, policymakers should offer subsidies, tax breaks, or low-interest loans as incentives for investing in new technology and digital solutions.
- **Scale Optimization Support:** Scale-related inefficiencies resulted in productivity losses for companies such as Valley Cement and TCI. Governmental initiatives could solve this by providing technological support for effectively growing operations. Reducing inefficiencies and maximising resource utilisation are two benefits of policies designed to direct businesses towards ideal production scales.
- **Establish Benchmarking programs:** Peer benchmarking in the study demonstrates that specific factories, such as Valley Cement and Cemtac Cement, function as efficiency models. Governments can encourage the adoption of industry-wide benchmarking systems, which will enable businesses to take management and resource-use best practices from top-performing plants.
- **Enhance access to capital for smaller firms:** Due to restricted funding, businesses that have encountered inefficiencies may find it difficult to invest in the essential modifications. A focused financial strategy, such grants for productive and energy-efficient equipment or special financing availability, could assist these businesses in improving output and cutting down on inefficiencies.
- **Collaborative Industry Forums:** Facilitating forums for discussion among government agencies, business executives, and technology specialists would promote cooperative problem-solving. These forums might facilitate the sharing of innovations and best practices within the industry and aid in identifying shared difficulties.

- **Implement advanced emission control technologies:** Install and regularly maintain dust collection systems such as baghouse filters, electrostatic precipitators, and wet scrubbers to capture and reduce PM10 emissions. Use modern, energy-efficient kilns and adopt cleaner production technologies that generate fewer particulate emissions.

- **Enhance process optimization:** Plants should optimize raw material handling and processing to minimize dust generation. Implement continuous monitoring and control systems to detect and address PM10 emissions in real-time.

- **Regular Monitoring and Reporting:** Conduct regular air quality monitoring around the cement plant to track PM10 levels and ensure compliance with environmental standards. Transparently report PM10 emission levels to regulatory authorities and the public to maintain accountability.

- **Adopt Sustainable Practices:** Implement sustainability initiatives that reduce overall environmental impact, such as using alternative fuels and raw materials that produce less particulate matter.

- Commit to continuous improvement and innovation in production processes to enhance environmental performance.

- **Ergonomic Assessments and Interventions:** Industries should conduct regular ergonomic assessments to identify potential risk factors in the workplace and provide training for employees on proper ergonomic practices and posture.

- **Health & Safety Programs:** Develop and enforce robust health and safety policies that comply with industry standards and regulations. Conduct regular health and safety audits to ensure compliance and identify areas for improvement. Provide personal protective equipment (PPE) and ensure its proper use and maintenance.

- **Workplace Environment Improvements:** Ensure adequate ventilation and air quality to prevent respiratory issues. Maintain a clean and hygienic work environment to reduce the risk of infections and other health problems.

- **Employee Training:** Educate employees about the importance of health and safety practices. Provide training on how to use equipment safely and maintain a healthy work environment.

- **Feedback Mechanism:** Establish channels for employees to report health concerns and ergonomic issues without fear of retaliation. Act on feedback promptly to address any identified health risks or discomforts.

- **Regular Review and Improvement**: Continuously review and update health and safety policies based on the latest research and industry best practices. Engage with employees regularly to understand their needs and make necessary adjustments to workplace conditions.

- A number of recommendations are made in light of the findings to improve policy implementation and regulatory compliance in the cement industry. Regulatory bodies ought to persist in their oversight and implementation of extant protocols, including NCAP, OHS, and MWP, to guarantee ecological sustainability, occupational safety, and equitable labour standards throughout all cement manufacturing facilities.

- Furthermore, it is imperative to cultivate cooperation among regulatory agencies, industry participants, and pertinent associations in order to share optimal methodologies and advance ongoing enhancements in policy compliance and ecological responsibility in the sector.

- In order to develop targeted interventions and strategies for improving policy implementation and sustainability, future research endeavours should investigate additional factors influencing policy implementation within the cement industry, such as organisational culture, management practices, and external market dynamics.

8.7 Implications

8.7.1: Theoretical Implications

This study, which focusses on the cement sector within a particular regional context, adds to the body of knowledge already available on industrial efficiency, environmental effect, and regulatory compliance. It offers a theoretical framework for comprehending the interactions between social, economic, and environmental variables in industrial sectors such as cement manufacturing. A systematic approach to analysing productivity improvements and finding important performance variables that can be applied to various industries and areas is provided by the use of Data Envelopment Analysis (DEA) and the Malmquist Productivity Index to evaluate firm-level efficiency. The results add to the theoretical debates in industrial economics and operations management by highlighting the significance of including scale optimisation and technological innovation as vital variables affecting productivity and efficiency.

The study also contributes to a better theoretical understanding of how economic activity and environmental deterioration are related, especially by emphasising how air quality trends vary according to seasonal and geographical changes. This contributes to a deeper theoretical conversation about how industry- and region-specific factors influence environmental results. Furthermore, the study's social efficiency component offers a theoretical framework for assessing labour practices and workplace fairness, highlighting the importance of worker satisfaction and fair labour standards as essential components of industrial sustainability.

The theoretical understanding of regulatory compliance in industrial contexts is aided by the examination of government policies such as the National Clean Air Programme, Occupational Health and Safety laws, and the Minimum Wage Policy. It draws attention to the intricate relationship between socioeconomic variables and policy adherence and makes the argument that having policies in place alone is insufficient in the absence of robust enforcement and customised implementation tactics. This develops the idea of how regulation and governance contribute to industrial sustainability.

8.7.2: Practical Implications:

The study's conclusions have a number of applications for stakeholders in the cement sector, legislators, and business professionals.

- **Improvement of industrial productivity:** Kashmiri cement companies may learn a lot from the high-achieving companies in the research, like Khyber Cement, which increased productivity significantly by using resource management and technical improvements. Similar tactics can be used by cement companies who are experiencing inefficiencies to increase productivity. These include making investments in new technologies, growing operations effectively, and improving managerial techniques.

- **Environmental Management:** The environmental findings highlight the necessity of mitigation techniques tailored to each region in order to properly manage air pollution. Cement facilities need to use cleaner technology, tighten emission regulations, and conduct ongoing air quality monitoring, especially those located in high-pollution areas like Khanmoh and Khrew. The report also makes the case that cooperation between communities and local government is necessary to guarantee efficient environmental management and the preservation of public health.
- **Enhancing Social Efficiency:** The study's findings about job satisfaction, worker health, and safety suggest doable actions cement companies may take to enhance working conditions. Businesses should prioritise raising occupational safety standards, improving access to healthcare, and maintaining fair and open labour practices. Resolving concerns with pay, equitable promotions, and employee perks may enhance job satisfaction and staff stability, which in turn may result in increased operational efficiency.
- **Policy Implementation and compliance:** The results of the study can be used by policymakers to improve cement industry regulations and enforcement procedures. According to the study, regulatory bodies should concentrate on raising management and staff understanding of policies by holding workshops and training sessions. This will help to ensure that rules pertaining to occupational health and safety, minimum wage, and environmental standards are properly comprehended and put into practice. Enhancing interagency cooperation and maintaining consistent monitoring can guarantee the industry's viability and improve compliance even further.
- **Stakeholder Collaboration:** The report emphasises how crucial multi-stakeholder participation is to accomplishing sustainability objectives. In order to ensure that industry expansion is in line with the more general objectives of public health, social equity, and environmental conservation, cement businesses, regulatory bodies, and local communities should collaborate to address environmental and social challenges.

The study's theoretical and practical insights have the potential to significantly improve industrial efficiency, foster environmental sustainability, improve worker welfare, and fortify policy compliance. All of these benefits could pave the way for Kashmir's cement industry to become more competitive and sustainable.

8.8: Scope for future research:

Future research can be carried out to cover the following research areas:

- **Comprehensive Economic Analysis:** Although the current study concentrated on production efficiency, other economic aspects including profitability, cost-effectiveness, and market competitiveness might be the subject of future investigations. A more comprehensive understanding of the economic efficiency of Kashmir's cement factories may be obtained by examining their long-term sustainability and financial standing.
- **Longitudinal Environmental impact:** The study looked at how particulate matter over a given time period degraded air quality. This analysis could be extended in the future over a longer period of time to evaluate trends and the environmental effects of cement manufacturing in the long run. A more thorough environmental assessment might also be obtained by looking into additional environmental issues including soil and water contamination.
- **Comparative Analysis:** It could be beneficial to compare the cement industry in Kashmir with other parts of India and the world. This will identify best practices that may be used in Kashmir and offer insights on the relative sustainability and efficiency of various techniques.
- **Impact of technological advancements:** Subsequent investigations may examine how technology advancements enhance the sustainability and efficiency of the cement sector. This covers automation, the use of green technologies, and improvements in manufacturing methods.
- **Supply chain and logistics Efficiency:** Future studies could also examine the logistics and supply chain within the cement sector. Operational efficiency depends on the effectiveness of distribution networks, the supply chain as a whole, and the acquisition of raw materials.
- **Sustainability Reporting and Transparency:** Subsequent studies may examine the degree of transparency and sustainability reporting in Kashmir's cement sector. Analysing how businesses disclose their social and environmental effects as well as how well these reports work to encourage sustainable behaviours would be part of this.

8.9 Limitations of Study

Although this study offers insightful information about the social, political, environmental, and economic aspects of Kashmir's cement business, it is not without flaws:

8.9.1: Data Availability and Quality:

The research relied on a mix of primary (e.g., surveys and questionnaires) and secondary sources (e.g., industry reports and pollution monitoring data). However, inconsistencies in the monitoring of environmental parameters, such as air quality (especially PM10 levels), and the lack of standardized economic reporting across plants introduced potential gaps. Economic data, particularly production efficiency metrics, may be underreported or not uniformly maintained across plants, affecting the reliability of the efficiency analysis.

8.9.2: Geographical Scope:

The scope of the study is geographically limited to cement plants in the Kashmir region. The findings thus reflect region-specific socioeconomic, cultural, and environmental contexts, and cannot be generalized to cement industries in other Indian states or global contexts, where operational standards, labor practices, and regulatory mechanisms may differ significantly.

8.9.3: Time Frame Constraints:

The study's economic analysis is confined to the years 2021–2023. This narrow time frame limits the ability to assess long-term performance trends, resilience to economic shocks (e.g., post-COVID recovery), or the cumulative impacts of gradual technological or policy shifts. Short-term data may not adequately capture cyclical variations in cement demand or the evolution of emissions management practices.

8.9.4:Limited Focus on Qualitative Insights:

While the study incorporates robust quantitative techniques such as Data Envelopment Analysis (DEA), Malmquist Productivity Index (MPI), and regression models, it lacks in-depth qualitative insights. Aspects such as worker satisfaction, labor union activity, gender-based discrimination, and the nuances of policy implementation could be better understood through qualitative interviews, focus groups, or ethnographic fieldwork.

8.9.5: Technology and Policy Impact Assessment:

Although government policies and technology adoption were included in the framework, the study does not fully capture the complexities of how external factors—such as global climate policy shifts, international trade regulations, or technological diffusion—may influence the cement sector in Kashmir. Furthermore, the disparity between policy design and ground-level enforcement remains a blind spot.

8.9.6: Regional Environmental Factors and Attribution Issues:

The environmental component, particularly the analysis of PM10 levels, assumes a direct correlation with cement plant emissions. However, ambient air quality is affected by various exogenous factors like road dust, vehicular traffic, domestic heating, and seasonal agricultural burning. Without source apportionment data, it may be inaccurate to attribute air quality deterioration solely to the cement sector.

8.9.7: Policy Compliance Measurement Challenges:

The study uses statistical tools like chi-square tests and cross-tabulations to evaluate policy compliance. However, this assumes a somewhat linear and transparent link between policy presence and its implementation. In practice, informal labor practices, political interference, and lack of local enforcement may skew actual compliance levels, making the measurement somewhat idealized.

8.9.8: Social Construct Limitations:

Constructs such as fairness, equity, and safety are inherently complex and influenced by social norms, cultural expectations, and personal perceptions. Quantifying them using survey data may lead to oversimplification, as such experiences vary significantly across workers and may be influenced by factors such as caste, gender, or employment status (permanent vs. contractual).

8.9.9: Stakeholder Representation Bias:

Although data were collected from managers and stakeholders, there might be a bias in responses due to social desirability or institutional pressure. Workers' voices, especially those in informal roles or marginalized communities, may remain underrepresented, limiting the ability to assess true conditions on the ground.

8.9.10: Exclusion of Circular Economy Metrics:

The study does not incorporate indicators related to circular economy practices, such as clinker substitution, fly ash utilization, or recycling of industrial waste. These are increasingly relevant to sustainability evaluations in the cement sector, especially from a global policy perspective.

8.9.11: Time Frame Inconsistency Across Objectives

The study utilizes different time periods for each objective due to data availability constraints. The economic efficiency analysis is based on limited secondary data available only for the period 2021–2023. In contrast, the social aspect and assessment of government policies are based on primary data collected through field surveys. Additionally, the environmental analysis would have benefitted from a longer-term dataset to capture actual pollution trends more accurately and provide a clearer understanding of environmental impacts. This variation in time frames may affect the comparability across objectives; however, each component offers meaningful insights within its available context

Bibliography

- Abdullayev, I. N., & Umirzakov, Z. A. (2021). Efficiency of Fabric in The Systems of Dust and Gas Cleaning of Cement Production.
- Abdul-Wahab S (2006) Impact of fugitive dust emissions from cement plants on nearby communities. Ecol Modell 195:338–348
- Abdul-Wahab, S. A., Al-Dhamri, H., Ram, G., & Chatterjee, V. P. (2021). An overview of alternative raw materials used in cement and clinker manufacturing. *International Journal of Sustainable Engineering*, *14*(4), 743-760.
- Adhikary, A. (2024). *Sustainability In the Indian Cement Industry*. Authors Click Publishing.
- Adshead, D., Thacker, S., Fuldauer, L. I., & Hall, J. W. (2019). Delivering on the Sustainable Development Goals through long-term infrastructure planning. *Global Environmental Change*, *59*, 101975.
- Agber T, Iorgirim S (2013) Assessment of air quality around Dangote Cement Company, TseKucha, Gboko, Benue State, Nigeria. Paper presented at the Proceedings of the 13th International Conference of Environmental Science and Technology. Athens, Greece 5th–7th September.
- Agresti, A. (2013). Categorical Data Analysis. John Wiley & Sons.
- Ahmed, M., Bashar, I., Alam, S. T., Wasi, A. I., Jerin, I., Khatun, S., & Rahman, M. (2021). An overview of the Asian cement industry: Environmental impacts, research methodologies, and mitigation measures. *Sustainable Production and Consumption*, *28*, 1018-1039.
- Aigbedion, I.N, 2005, Environmental pollution in the Niger Delta, Nigeria. Inter-disciplinary Journal Enugu – Nigeria, 3(4), 205–210.
- Akpan O, Amodu E, (2011) An assessment of the major elemental composition and concentration in limestones samples from Yandev and Odukpani areas of Nigeria using nuclear techniques. J Environ Sci Technol 4:332–339
- Al Salhen, K. S. (2014). Assessment of oxidative stress, hematological, kidney and liver function parameters of Libyan cement factory workers. *Journal of American science*, *10*(5), 58-65.

- Ali, Ifzai and Hyun Hwa Son (2007): "Measuring Inclusive Growth", *Asian Development Review*, Vol.24, No.1, pp 11-31.
- Al-Neaimi, Y. I., Gomes, J., & Lloyd, O. L. (2001). Respiratory illnesses and ventilatory function among workers at a cement factory in a rapidly developing country. *Occupational Medicine*, *51*(6), 367-373.
- Amran, M., Makul, N., Fediuk, R., Lee, Y. H., Vatin, N. I., Lee, Y. Y., & Mohammed, K. (2022). Global carbon recoverability experiences from the cement industry. *Case Studies in Construction Materials*, *17*, e01439.
- Amankwah, E. K., Conley, A. P., & Reed, D. R. (2013). Epidemiology and therapies for metastatic sarcoma. *Clinical epidemiology*, 147-162.
- Amrina, E., & Aridharma, D. (2016, December). Sustainable maintenance performance evaluation model for the cement industry. In *2016 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)* (pp. 350-354). IEEE.
- An, J., Middleton, R. S., & Li, Y. (2019). Environmental performance analysis of cement production with CO 2 capture and storage technology in a life-cycle perspective. Sustainability 11 (9): 2626.
- Andrew, R. M. (2019). Global CO2 emissions from cement production. *Earth System Science Data*, *11*(4), 1675-1710.
- Arici, C., Ronda-Pérez, E., Tamhid, T., Absekava, K., & Porru, S. (2019). Occupational Health and Safety of Immigrant Workers in Italy and Spain: A Scoping Review. *International Journal of Environmental Research and Public Health*, 16. https://doi.org/10.3390/ijerph16224416.
- Arli, D., Van Esch, P., Northey, G., Lee, M. S., & Dimitriu, R. (2019). Hypocrisy, skepticism, and reputation: the mediating role of corporate social responsibility. *Marketing Intelligence & Planning*, *37*(6), 706-720.
- Arthurson, K. (2002). Creating inclusive communities through balancing social mix: A critical relationship or tenuous link? Urban Policy and Research, 20(3), 245–261.

- Ashraf M, Bhat GA (2013). Impact of Cement Dust on Soil and Vegetation around Khrew Cement Factories. M. Phil. Dissertation, University of Kashmir, Srinagar-190006, pp: 15.
- Asongu, S. A., Nnanna, J., &Acha-Anyi, P. N. (2020). Inequality and gender economic inclusion: The moderating role of financial access in Sub-Saharan Africa. *Economic Analysis and Policy*, *65*, 173-185.
- Ataei, P., Karimi, H., Moradhaseli, S., & Babaei, M. H. (2022). Analysis of farmers' environmental sustainability behavior: the use of norm activation theory (a sample from Iran). *Arabian Journal of Geosciences*, *15*(9), 859.
- Aydin, S., Aydin, S., Croteau, G. A., Sahin, I., & Citil, C. (2010). Ghrelin, nitrite and paraoxonase/arylesterase concentrations in cement plant workers. *Journal of medical Biochemistry*, *29*(2), 78-83.
- Babbie, E. R., & Rubin, A. (2016). Empowerment series: Research methods for social work.
- Balsara, S., Jain, P. K., & Ramesh, A. (2021). An integrated methodology to overcome barriers to climate change mitigation strategies: a case of the cement industry in India. *Environmental Science and Pollution Research*, *28*, 20451-20475.
- Balakrishnan, K., Blouin, J. L., & Guay, W. R. (2019). Tax aggressiveness and corporate transparency. *The Accounting Review*, *94*(1), 45-69.
- Bandyopadhyay, S. (2010). Effect of regulation on efficiency: evidence from Indian cement industry. *Central European Journal of Operations Research*, *18*(2), 153-170
- Banerjee, S. (2007). "Environmental regulation and technical efficiency: a data envelopment analysis for Indian cement industry", Discussion Paper, ERU/2007 – 01, National Institute of Public Finance and Policy, New Delhi
- Barrientos, A., & Villa, J. M. (2016). Economic and political inclusion in human development conditional income transfer programmes in Latin America. *Social Policy and Society*, *15*(3), 421-433.

- Basiago, A. D. (1998). Economic, social, and environmental sustainability in development theory and urban planning practice. *Environmentalist*, *19*(2), 145-161.
- Bates P and Repper J (2001) Social inclusion: A framework for evaluation. *A Life in the Day* 5: 18–23.
- Beketie, K. T., Angessa, A. T., Zeleke, T. T., & Ayal, D. Y. (2022). Impact of cement factory emission on air quality and human health around Mugher and the surrounding villages, Central Ethiopia. Air Quality, Atmosphere & Health, 15(2), 347-361.
- Benedetti, M, (2017). Assessing and improving compressed air system's energy efficiency in production and use: Findings from an explorative study in large and energy-intensive industrial firms. Energy Procedia, 105, 3112-3117.
- Bermudez, G. M., Moreno, M., Invernizzi, R., Plá, R., & Pignata, M. L. (2010). Evaluating topsoil trace element pollution in the vicinity of a cement plant and a former open-cast uranium mine in central Argentina. *Journal of soils and sediments*, *10*, 1308-1323.
- Benhelal, E., Shamsaei, E., & Rashid, M. I. (2021). Challenges against CO2 abatement strategies in cement industry: A review. *Journal of Environmental Sciences*, *104*, 84-101.
- Bhat, M. A., Gaga, E. O., & Özkan, A. (2022). A New Approach Within AHP Framework for Prioritization of Air Quality Management in Kashmir. In *Biodiversity, Conservation and Sustainability in Asia: Volume 2: Prospects and Challenges in South and Middle Asia* (pp. 981-995). Cham: Springer International Publishing.
- Bianchi, C., & Bianchi, T. (2007). Malignant mesothelioma: global incidence and relationship with asbestos. *Industrial Health*, *45*(3), 379-387.
- Bibi, U.; Balli, H.O.; Matthews, C.D.; Tripe, D.W.L. Impact of gender and governance on micro finance efficiency. J. Int. Finance. Mark. Inst. Money **2018**, 53, 307–319
- Böhm, M., & Pierkes, R. (2009). Evaluation of Portland cement clinker with optical microscopy-Case Studies. *Proceedings of the 12th Euroseminar on Microscopy Applied to Building Materials, Dortmund, Germany, September*, 15-19.
- Bos, K., & Gupta, J. (2016). Inclusive development, oil extraction and climate change: a multilevel analysis of Kenya. International Journal of Sustainable Development & World Ecology, 1-11.

- Brechin, S. R., Wilshusen, P. R., Fortwangler, C. L., & West, P. C. (2003). Contested nature conservation and development at the turn of the twenty-first century. In *Contested nature: Promoting international biodiversity conservation with social justice in the twenty-first century* (pp. 1-22). State University of New York Press.
- Brundtland, G.H., 1987. Report of the World Commission on Environment and Development: Our Common Future. UN.
- Brus, D. J. (2022). Systematic random sampling. *Spatial Sampling with R*, 79-92.
- Bryman, A., 2008. Social Research Methods. Oxford University Press, Oxford. Bullen, K.A., 1989. Structural Equations with Latent Variables. Wiley, New York.
- Burange, L. G., & Yamini, S. (2009). Performance of the Indian cement industry: The competitive landscape. *Artha Vijnana*, *51*(3), 209.
- C. Muller, S. Palm, Cement grades with a low Portland cement clinker ratio for the concretes of the future, in: Bundesver band Deutsche Beton- und Fertigteil industries (Ed.), Sustainable Innovation: Proceedings 55th BetonTage, Neu-Ulm 10–11 February 2011. 86–89, 2011.
- Calderon, C. (2023). An industry business case for diversity, equity, and inclusion. *The APPEA Journal*, *63*(2), S44-S46.
- Callejón, M., & Segarra, A. (1999). Business dynamics and efficiency in industries and regions: The case of Spain. *Small Business Economics*, *13,* 253-271.
- Campbell, D.T., 1955. The informant in quantitative research. Am. J. Sociol.,339–342.Carroll, A.B., 1979. A three-dimensional conceptual model of corporate performance. Acad. Manage. Rev. 4 (4), 497–505.
- Campbell, J. L. (2007). Why would corporations behave in socially responsible ways? An institutional theory of corporate social responsibility. Academy of Management Review, 32, 946–967.
- Cantini, A., Leoni, L., De Carlo, F., Salvio, M., Martini, C., & Martini, F. (2021). Technological energy efficiency improvements in cement industries. *Sustainability*, *13*(7), 3810.

- Carter, C.R., Jennings, M.M., 2000. Purchasing's Contribution to the Socially Responsible Management of the Supply Chain. Center for Advanced Purchasing Studies, Tempe, AZ. Carter, C.R., Jennings, M.M., 2002. Social responsibility and supply chain relationships. Transp. Res. E: Logist. Transp. Rev. 38 (1), 37–52.
- Carter, C.R., Jennings, M.M., 2004. The role of purchasing in corporate social responsibility: a structural equation analysis. J. Bus. Logist. 25 (1), 145–186.
- Casteel, A., & Bridier, N. L. (2021). DESCRIBING POPULATIONS AND SAMPLES IN DOCTORAL STUDENT RESEARCH. *International Journal of Doctoral Studies*, *16*(1).
- Chand, P., Sirohi, S., Sirohi, S.K., 2015. Development and application of an integrated sustainability index for small-holder dairy farms in Rajasthan, India. Ecol. Indic. 56, 23–30.
- Chang, H.F. A Liberal Theory of SocialWelfare: Fairness, Utility, and the Pareto Principle. Yale Law J. **2000**, 110, 173–235
- Chari, L., Patil, N., & Mohanty, R. P. (2009). Assessment of technical and scale efficiencies of Indian cement industry using data envelopment analysis (DEA). *Available at SSRN 2013790*.
- Chaurasia S, Ahmad I, Gupta A, Kumar S (2014) Assessment of air pollution emission from cement industries in Nimbahera, Rajasthan. Int J Curr Microbiol App Sci 3:133–139
- Chaves, G. D. L. D., Siman, R. R., Ribeiro, G. M., & Chang, N. B. (2021). Synergizing environmental, social, and economic sustainability factors for refuse derived fuel use in cement industry: A case study in Espirito Santo, Brazil. *Journal of Environmental Management*, *288*, 112401.
- Chouhan, V., Sharma, R., & Goswami, S. (2021). Sustainable reporting practices of selected cement companies in India: A case study. *Accounting*, *7*(1), 151-160.
- Chaves, G. D. L. D., Siman, R. R., Ribeiro, G. M., & Chang, N. B. (2021). Synergizing environmental, social, and economic sustainability factors for refuse derived fuel use in

cement industry: A case study in Espirito Santo, Brazil. *Journal of Environmental Management*, *288*, 112401

- Chen, C., Habert, G., Bouzidi, Y., &Jullien, A. (2010). Environmental impact of cement production: detail of the different processes and cement plant variability evaluation. Journal of Cleaner Production, 18(5), 478-485.
- Chen, C., Habert, G., Bouzidi, Y., &Jullien, A. (2010). Environmental impact of cement production: detail of the different processes and cement plant variability evaluation. *Journal of Cleaner Production*, *18*(5), 478-485.
- Chen, C., Habert, G., Bouzidi, Y., Jullien, A., & Ventura, A. (2010). LCA allocation procedure used as an incitative method for waste recycling: An application to mineral additions in concrete. *Resources, Conservation, and Recycling*, *54*(12), 1231-1240.
- Chortareas, G.E.; Girardone, C.; Ventouri, A. Financial freedom and bank efficiency: Evidence from the European Union. J. Bank. Financ. **2013**, 37, 1223–1231.
- clusive_development/
- Coelli, T. J., Rao, D. S. P., O'Donnell, C. J., & Battese, G. E. (2005). *An introduction to efficiency and productivity analysis*. springer science & business media.
- Cook, S, (2006), "Structural Change, growth and poverty reduction in Asia: Pathways to inclusive development", Development Policy Review, Vo1.24, No. 1, 5 1-80.
- Coombs,T., Nicholas, A., &Pirkis, J. (2013). A review of social inclusion measures. *Australian & New Zealand Journal of Psychiatry*, *47*(10), 906-919.
- Cowell, M. M. (2013). Bounce back or move on: Regional resilience and economic development planning. *Cities*, *30*, 212-222.
- Daniels, M. R. (1969). Differences in efficiency among industries in developing countries. *The American Economic Review*, *59*(1), 159-171.
- Dar AR, Dar GH (2006) The wealth of Kashmir Himalaya-Gymnosperms. Asian J Plant Sci 52:251–259
- Dar, M. N., Manzoor, M. F., Kaushik, V., Kumar, M., Rawat, S., Shah, K. M., ...& Singh, E. A. (2017). Water Quality assessments of Dal Lake, Jammu & Kashmir. *International journal of scientific & engineering research*, *8*, 12.

- Dar, M. N., Manzoor, M. F., Kaushik, V., Kumar, M., Rawat, S., Shah, K. M., ...& Singh, E. A. (2017). Water Quality assessments of Dal Lake, Jammu & Kashmir. *International journal of scientific & engineering research*, *8*, 12.
- Dar, M. N., Manzoor, M. F., Kaushik, V., Kumar, M., Rawat, S., Shah, K. M., ...& Singh, E. A. (2017). Water Quality assessments of Dal Lake, Jammu & Kashmir. *International journal of scientific & engineering research*, *8*, 12.
- Dasgupta, D., & Das, S. (2021). Sustainability performance of the Indian cement industry. *Clean Technologies and Environmental Policy*, *23*, 1375-1383.
- Davidavičienė, V. (2018). Research methodology: An introduction. In Modernizing the Academic Teaching and Research Environment: Methodologies and Cases in Business Research (pp. 1–23).
- Dawoudian, J., Bahamin, S., &Tantoh, H. B. (2021). Environmental impact assessment of cement industries using mathematical matrix method: the case of Ghayen cement, South Khorasan, Iran. Environmental Science and Pollution Research, 28(18), 22348-22358.
- Dawoudian, J., Bahamin, S., &Tantoh, H. B. (2021). Environmental impact assessment of cement industries using mathematical matrix method: case of Ghayen cement, South Khorasan, Iran. *Environmental Science and Pollution Research*, *28*(18), 22348-22358.
- De Magalhães, L., Santaeulàlia-Llopis, R., 2018. The consumption, income, and wealth of the poorest: An empirical analysis of economic inequality in rural and urban sub-Saharan Africa for macroeconomists. J. Dev. Stud. 134 (September), 350–371.
- Deja, J., Uliasz-Bochenczyk, A., & Mokrzycki, E. (2010). CO_2 emissions from Polish cement industry. *International Journal of Greenhouse Gas Control*, *4*(4), 583-588.
- Devi, K. S., Lakshmi, V. V., & Alakanandana, A. (2017).Impacts of cement industry on environment-an overview. Asia Pac. J. Res, 1, 156-161.
- Dhar, S., Pathak, M., & Shukla, P. R. (2020). Transformation of India's steel and cement industry in a sustainable 1.5 C world. *Energy Policy*, *137*, 111104.Dorer G, Harries P and Marston L (2009) Measuring social inclusion: A staff survey of mental health service users' participation in community occupations. *British Journal of Occupational Therapy* 72: 520–530.

- Du Plessis, C. Agenda 21 for Sustainable Construction in Developing Countries; CSIR Report BOU/E0204; CSIR, UNEP-IET C: Pretoria, South Africa, 2002.
- Duque-Acevedo, M., Lancellotti, I., Andreola, F. et al. Management of agricultural waste biomass as raw material for the construction sector: an analysis of sustainable and circular alternatives. Environ Sci Eur 34, 70 (2022). https://doi.org/10.1186/s12302-022-00655-7
- Dyllick, T., & Hockerts, K. (2002). Beyond the business case for Corporate Sustainability. Business Strategy and the Environment, 11, 130–141. doi:10.1002/bse.323.
- Elkington, J. Towards the sustainable corporation: Win-win-win business strategies for sustainable development. Calif. Manag. Rev. Berkeley **1994**, 36, 90.
- El-Salamony, A. H. R., Mahmoud, H. M., & Shehata, N. (2020). Enhancing the efficiency of a cement plant kiln using modified alternative fuel. *Environmental nanotechnology, monitoring & management*, *14*, 100310.
- Energy Information Administration (EIA). Annual Energy Review 2011; Energy Information Administration: Washington, DC, USA, 2012.
- Essama-Nssah, B., Pereira da Silva, L. A., & Samake, I. (2002). A Poverty Analysis Macroeconomic Simulator (PAMS) Linking household surveys with macro-models. *Available at SSRN 636251*.
- Etim, M. A., Babaremu, K., Lazarus, J., & Omole, D. (2021). Health risk and environmental assessment of cement production in Nigeria. *Atmosphere*, *12*(9), 1111.
- Fayaz, S., Rather, G. M., Naqshbandi, Z. K., & Bhat, M. S. (2017). INDOOR AIR QUALITY AND ITS IMPACT ON THE HEALTH OF GUJJARS OF NORTH KASHMIR HIMALAYAS. JOURNAL OF INDIAN RESEARCH, 5(2), 50-61.
- Fedii, O. (2018). DEMOGRAPHIC POLICY IN A SCHOOL COURSE OF GEOGRAPHY. *THE SOURCES OF PEDAGOGICAL SKILLS*. https://doi.org/10.33989/2075-146x.2018.22.185295.
- Fleming, A., Wise, R. M., Hansen, H., &Sams, L. (2017). The sustainable development goals: A case study. *Marine Policy*, *86*, 94-103.

- Formal, C., & Larker, D. F. (1981). Evaluating structural equations models with unobservable variables and measurement error.
- Frankental, P., 2001. Corporate social responsibility e a PR invention? Corporate Communications: An International Journal 6 (1), 18e23.
- Freeman john R (1989) Democracy and markets: *The politics of mixed economies*. Ithaca: Cornell University Press.
- Galema, R.; Koetter, M. European Bank Efficiency and Performance: The Effects of Supranational Versus National Bank Supervision. In The Palgrave Handbook of European Banking; Palgrave Macmillan: London, UK, 2016; pp. 257–292. ISBN 978-1-137-52143-9.
- Gallego-Álvarez, I., Galindo-Villardón, M.P., Rodríguez-Rosa, M., 2015. Evolution of sustainability indicator worldwide: a study from the economic perspective based on the X-STATICO method. Ecol. Indic. 58, 139–151.
- Ganaie, D. B., Malhotra, A., & Wani, I. A. (2022). Water quality assessment of Mansbal Lake in Kashmir. *Water Science*, *36*(1), 114-124.
- Gartner, E., & Hirao, H. (2015). A review of alternative approaches to the reduction of CO2 emissions associated with the manufacture of the binder phase in concrete. Cement and Concrete Research, 78, 126-142.
- Geneva: World Health Organisation
- Ghorani-A R-Z, Balali-Mood M (2016) Effects of air pollution on human health and practical measures for prevention in Iran. J Res Med Sci 21:65
- Ghosh, S., & Kathpalia, J. (2020). *Production Efficiency in the Indian Cement Industry: A State-wise Analysis.* Journal of Cleaner Production, 252, 119683.
- Ghulam, Y., & Jaffry, S. (2015). Efficiency and productivity of the cement industry: Pakistani experience of deregulation and privatization. *Omega*, *54*, 101-115.
- Gladwin, T.N., Kennelly J.J. and Krause T-S. (1995), “Shifting Paradigms for Sustainable Development: Implications for Management Theory and Research”, the Academy of Management Review, Vol. 20, No. 4, pp. 874-907

- Global Reporting Initiative. (2015). Retrieved on 15 December 2016 from\https://www.globalreporting.org/resourcelibrary/GRIG4-Part1-Reporting-Principles-and Standard-Disclosures.pdf.
- Global reporting Initiatives. (2002). Retrieved December 11, 2014 from https://www.globalreporting.org/reporting/G3andg3-1/guidelines online/TechnicalProtocol/Pages/MaterialityInTheContextOfTheGRIReportingFramework.aspx.
- Goodland H. 1995. The concept of sustainability.Annu. Rev. Ecol. Syst. 26:1–24

- Goodland H. 1995. The concept of sustainability.Annu. Rev. Ecol. Syst. 26:1–24

- Gupta, J., &Vegelin, C. (2016).Sustainable development goals and inclusive development. *International environmental agreements: Politics, law and economics*, *16*(3), 433-448.
- Gupta, S., Mohapatra, B. N., & Bansal, M. (2020). A review on development of Portland limestone cement: A step towards low carbon economy for Indian cement industry. *Current Research in Green and Sustainable Chemistry*, *3*, 100019.
- Gupta, J., V. Cornellissen& M. Ros-Tonen (2015). Inclusive Development, Encyclopaedia
- Gutierrez-Goiria, J., San-Jose, L., & Retolaza, J. L. (2017). Social efficiency in microfinance institutions: Identifying how to improve it. *Journal of International Development*, *29*(2), 259-280.
- Gutierrez-Goiria, J.; San-Jose, L.; Retolaza, J.L. Social Efficiency in Microfinance Institutions: Identifying How to Improve It. J. Int. Dev. **2017**, 29, 259–280.
- Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. *Journal of Marketing theory and Practice*, *19*(2), 139-152.

- Hák, T., Janoušková, S., & Moldan, B. (2016). Sustainable Development Goals: A need for relevant indicators. *Ecological indicators*, *60*, 565-573.
- Hao, X., Wen, S., Xue, Y., Wu, H., & Hao, Y. (2023). How to improve the environment, resources and economic efficiency in the digital era?. *Resources Policy*, *80*, 103198.
- Hewings, G. J. (2020). Regional input-output analysis.

- Holloway, S.; Parrish, K. The contractor's role in the sustainable construction industry. Proc. Inst. Civ. Eng. Eng. Sustain. **2015**, 168, 53–60.
- Honneth, A. (2023). Democracy and Fair Labor Conditions. *Journal of Business Ethics, 184*(1), 1-10.
- Hosseinijou, S. A., Mansour, S., & Shirazi, M. A. (2014). Social life cycle assessment for material selection: a case study of building materials. *The International Journal of Life Cycle Assessment*, *19*, 620-645.
- Howes, M., Wortley, L., Potts, R., Dedekorkut-Howes, A., Serrao-Neumann, S., Davidson, J., ... & Nunn, P. (2017). Environmental sustainability: a case of policy implementation failure?. *Sustainability*, *9*(2), 165.
- http://www.undp.org/content/undp/en/home/ourwork/povertyreduction/focus_areas/focus_in
- Htun, M. (2014).Political inclusion and representation of afrodescendant women in Latin America. *Representation: the case of women,* 118-136.
- Huntzinger, D. N., & Eatmon, T. D. (2009). A life-cycle assessment of Portland cement manufacturing: comparing the traditional process with alternative technologies. *Journal of cleaner production*, *17*(7), 668-675.
- Huang, F., Hu, Z., Li, S., Liu, J., Han, F., & Liu, J. (2023). Long-term deformation and mechanical properties evolution of cement paste with ultra-low water-to-cement ratio driven by water migration. *Journal of Building Engineering*, *76*, 107250.
- Ighalo, J. O., & Adeniyi, A. G. (2020).A perspective on environmental sustainability in the cement industry. *Waste Disposal & Sustainable Energy*, *2*(3), 161-164.
- J. Harder, Development of clinker substitutes in the cement industry, Zement- Kalk-Gips 59 (2) (2006) 58–64. [17] B. Hauer, H. Klein, Recycling of concrete.
- Jain, V., Sharma, K., & Gupta, P. (2018). *Scale Economies and Production Efficiency in the Cement Industry: Evidence from India.* Economic Modelling, 75, 345-354.
- Jehangir, A., Dar, N. A., Yousuf, A. R., & Sofi, A. H. (2011).Air quality at Sonamarg-a tourist hill station in Kashmir valley, India. Journal of Experimental Sciences, 2(6).

- Jha, A. K., & Sivapullaiah, P. V. (2001). Mechanism of improvement in the strength and volume change behavior of lime stabilized soil. *Engineering Geology*, *198*, 53-64.
- Jones, M. (2019). "Occupational Health and Safety Policies and Their Socioeconomic Impact." Industrial Health Review, 28(4), 211-226.
- Joshi, T., & Smith, K. (2002). Occupational health in India.. *Occupational medicine*, 17 3, 371-89, iii-iv.
- K. Bauer, V. Hoenig, Energy efficiency of cement plants, Cement International 8 (3) (2010) 148–152.
- Kajaste, R., & Hurme, M. (2016). Cement industry greenhouse gas emissions–management options and abatement cost. *Journal of cleaner production*, *112*, 4041-4052.
- Kang, D., & Lee, D. H. (2016). Energy and environment efficiency of industry and its productivity effect. *Journal of Cleaner Production*, *135*, 184-193.
- KARAHAN, V., & AKOSMAN, C. (2018). Occupational health risk analysis and assessment in cement production processes. *Turkish Journal of Science and Technology*, *13*(2), 29-37.
- Kates, R. W., Leiserowitz, A. A., & Parris, T. M. (2005). Accelerating sustainable development. *Environment*, *47*(5), 0_2.
- Keogh, J. W., Kilding, A., Pidgeon, P., Ashley, L., & Gillis, D. (2009). Physical benefits of dancing for healthy older adults: a review. *Journal of aging and physical activity*, *17*(4), 479-500.
- Khaviya, S., Kavitha, S., & Manoj, S. (2017). A risk assessment study on occupational hazards in the cement industry. *Int Res J Eng Technol*, *4*, 12.
- Kniivilä, M. (2007). Industrial development and economic growth: Implications for poverty reduction and income inequality. *Industrial development for the 21st century: Sustainable development perspectives*, *1*(3), 295-333.
- Kolo, M. T., Khandaker, M. U., & Shuaibu, H. K. (2019). Natural radioactivity in soils around the mega coal-fired cement factory in Nigeria and its implications on human health and environment. *Arabian Journal of Geosciences*, *12*, 1-11.
- Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.

- Kukreja, K., Soni, M. K., Mohapatra, B., & Panda, D. K. (2023). Impact assessment of alternative fuels on production Cost, plant operation and Environmental study of Indian cement industry. *Sustainable Energy Technologies and Assessments*, *57*, 103300.
- Kumar, R., Gupta, S., & Singh, A. (2020). "Impact of Regulatory Policies on the Cement Industry: A Socioeconomic Perspective." International Journal of Industrial Economics, 12(3), 289-305.
- Kynclova, P., Upadhyaya, S., & Nice, T. (2020). Composite index as a measure on achieving Sustainable Development Goal 9 (SDG-9) industry-related targets: The SDG-9 index. *Applied Energy*, *265*, 114755.
- Lawshe, C. H. (1975). A quantitative approach to content validity. *Personnel psychology*, *28*(4).
- Lebovics, M.; Hermes, N.; Hudon, M. Are Financial and Social Efficiency Mutually Exclusive? A Case Study of Vietnamese Microfinance Institutions. Ann. Public Coop. Econ. **2016**, 87, 55–77
- Lefeber, L., & Vietorisz, T. (2007). The meaning of social efficiency. *Review of Political Economy*, *19*(2), 139-164. https://doi.org/10.1080/09538250701256672
- Leonard, T. C. (2000). The very idea of applying economics: The modern minimum-wage controversy and its antecedents. *History of Political Economy*, *32*(Suppl_1), 117-144.
- Leunig, T. (2011). Cart or horse: Transport and economic growth.
- Li, Y. (2015). Towards inclusive and sustainable industrial development
- Li, Z., & Liu, H. (2022). How does tourism industry agglomeration improve tourism economic efficiency?. *Tourism Economics*, *28*(7), 1724-1748.
- Lira, J. S. D. M. M., Barros, L. B., & de Miranda, L. R. M. (2020). Bibliometric analysis on sustainability in the cement industry. *Brazilian Journal of Development*, *6*(10), 82372-82385.
- Liu, Y., Zhao, X., & Wang, J. (2018). "Socioeconomic Impacts of Environmental Policies on Industrial Sectors: A Case Study of the Cement Industry." Journal of Environmental Management, 206, 1248-1257.

- Long, X., Zhao, X., & Cheng, F. (2015). The comparison analysis of total factor productivity and eco-efficiency in China's cement manufactures. *Energy Policy*, *81*, 61-66.

- Lubis, M., Fauzi, R., Liandani, P., & Lubis, A. (2020). Information Security Awareness (ISA) towards the Intention to Comply and Demographic Factors: Statistical Correspondence Analysis. https://doi.org/10.1145/3411174.3411196.

- Madeira, J. (1974). [Towards a demographic policy].. *Notas de poblacion*, 2 6, 13-36 .
- Marmier, A. (2023). Decarbonisation options for the cement industry.
- Madlool, N. A., Saidur, R., Rahim, N. A., Islam, M. R., & Hossian, M. S. (2012). An exergy analysis for cement industries: an overview. *Renewable and Sustainable Energy Reviews*, *16*(1), 921-932.
- Mahmood, A. M., Wafi, N. A., & Shaikhani, M. A. (2010). Spirometric measurements among workers of Tasluja cement factory. *J Zankoy Sulamani*, *13*(1), 9-14.
- Maichum, K., Parichatnon, S., & Peng, K. C. (2017). The influence of environmental concern and environmental attitude on purchase intention towards green products: a case study of young consumers in Thailand. *International Journal of Business Marketing and Management*, *2*(3), 1-8.
- Masud, M., Akhatr, R., Nasrin, S., & Adamu, I. (2017). Impact of socio-demographic factors on the mitigating actions for climate change: a path analysis with mediating effects of attitudinal variables. *Environmental Science and Pollution Research*, 24, 26462-26477. https://doi.org/10.1007/s11356-017-0188-7.
- Mazumdar, K. (1999). Measuring the well-beings of the developing countries: achievement and improvement indices. *Social Indicators Research*, *47*, 1-60.
- McHugh, M. L. (2013). The chi-square test of independence. Biochemia Medica, 23(2), 143-149.
- McKinnon, A. (2010). Environmental sustainability. *Green logistics: improving the environmental sustainability of logistics. London*.

- Meadows D. 1998.Indicators and Information Systems for Sustainable Development. Hartland Four Corners, VT: Sustain. Inst.

- Mehraj, S. S., Bhat, G. A., Balkhi, H. M., &Gul, T. (2013). Health risks for the population living in the neighborhood of a cement factory. African Journal of Environmental Science and Technology, 7(12), 1044-1052.
- Mehta, P.K. (1998) Role of Pozzolanic and Cementitious Material in Sustainable Development of the Concrete Industry. Fly Ash, Silica Fume, Slag, and Natural Pozzolans in Concrete. Proceedings of the 6th CANMET/ACI/JCI International Conference, Bangkok. pp. 1–20
- Mekha, V., & Reddy, A. K. (2018). Experiences of Cement Industry in India. *International Journal of Research in Geography*, *4*, 72-78.
- Miernyk, W. H. (2020). The elements of input-output analysis.
- Mikulčić, H., Vujanović, M., & Duić, N. (2015). Improving the sustainability of cement production by using numerical simulation of limestone thermal degradation and pulverized coal combustion in a cement calciner. *Journal of cleaner production*, *88*, 262-271.
- Masmali, M. (2021). Implementation of lean manufacturing in a cement industry. *Engineering, Technology & Applied Science Research*, *11*(3), 7069-7074.
- Mishra, S. B., & Alok, S. (2022). Handbook of research methodology. Educreation Publishing.
- Mishra, U. C., Sarsaiya, S., & Gupta, A. (2022). A systematic review on the impact of cement industries on the natural environment. *Environmental Science and Pollution Research*, *29*(13), 18440-18451.
- Mishra, U. C., Sarsaiya, S., & Gupta, A. (2022). A systematic review on the impact of cement industries on the natural environment. *Environmental Science and Pollution Research*, 1-12.
- Mitchell, R. J., Irwin, R. E., Flanagan, R. J., & Karron, J. D. (2009). Ecology and evolution of plant–pollinator interactions. *Annals of botany*, *103*(9), 1355-1363.
- Mohamad, N., Muthusamy, K., Embong, R., Kusbiantoro, A., &Hashim, M. H. (2021). Environmental impact of cement production and Solutions: A review. Materials Today: Proceedings

- Mohamed, E. (2020). Economic, Social, and Environmental Dimensions of Development in Sudan.In *Perspectives on Economic Development-Public Policy, Culture, and Economic Development*. London, UK: IntechOpen
- Mokhtar, A., & Nasooti, M. (2020). A decision support tool for cement industry to select energy efficiency measures. *Energy Strategy Reviews*, *28*, 100458.
- Mudgal, V., & Chellasamy, A. (2024). Growth of Indian cement industry, its environment impact and emerging alternatives: A Review. *Indian Journal of Engineering and Materials Sciences (IJEMS)*, *31*(1), 38-50.
- Mukhtar, A., & Mukhtar, F. (2020). Air Pollution a Major Threat to the People of Khrew (J&K).
- N Khreisat, M., & Mugableh, A. I. (2020). Multidimensionality of EFL Recreational Reading Attitudes: An EFA and CFA Approach. *Journal of Research in Applied Linguistics*, *11*(2), 57-69.
- Nadeem, M., Ahmad, R., Ahmed, A., Ahmad, N., Batool, S. R., & Rehman, K. U. (2015). The effect of leverage on the financial health of the firms: A study from the cement industry of Pakistan. *Industrial Engineering Letters*, *5*(5), 123-126.
- Najam A, Cleveland CJ. Energy and sustainable development at global environmental summits: an evolving agenda. Environ Dev Sustain 2003;5:117–38
- Nayak, P. K., Chattopadhyay, S. K., Kumar, A. V., &Dhanya, V. (2010).Inclusive growth and its regional dimension. *Reserve Bank of India Occasional Papers*, *31*(3), 91-156.
- Ncube, M., Anyanwu, J.C., Hausken, K., 2014. Inequality, economic growth and poverty in the middle east and north Africa (MENA). Afr. Dev. Rev. 26 (3), 435–453.
- Ndiaya, C., & Lv, K. (2018). Role of industrialization on economic growth: the experience of Senegal (1960-2017). *American Journal of Industrial and Business Management*, *8*(10), 2072.
- Neghab, M., & Choobineh, A. (2007). Work-related respiratory symptoms and ventilatory disorders among employees of a cement industry in Shiraz, Iran. *Journal of occupational health*, *49*(4), 273-278.

- Nelson, J., 2004. The Public Role of Private Enterprise: Risks, Opportunities and New Models of Engagement. CSR Initiative. Working Paper 1. John F Kennedy School of Government, Harvard University, Cambridge, MA.
- Neumark, D. (2019). The econometrics and economics of the employment effects of minimum wages: Getting from known unknowns to known knowns. *German Economic Review*, *20*(3), 293-329.
- Ni, W.D., Thomas, B.J., 2004. Energy for sustainable development in China. Energy Policy 32, 1225–1229.
- Nidheesh, P. V., & Kumar, M. S. (2019). An overview of environmental sustainability in cement and steel production. *Journal of cleaner production*, *231*, 856-871.
- Nuño, R., Coleman, K., Bengoa, R., & Sauto, R. (2012). Integrated care for chronic conditions: the contribution of the ICCC Framework. *Health policy*, *105*(1), 55-64.
- of Global Environmental Politics and Governance, Edited by Philipp Pattberg and Fariborz
- Oguntoke, O., Awanu, A. E., & Annegarn, H. J. (2012). Impact of cement factory operations on air quality and human health in Ewekoro Local Government Area, South-Western Nigeria. *International journal of environmental studies*, *69*(6), 934-945.
- Olson, K. (2016). *Essentials of qualitative interviewing*. Routledge.
- Onwujekwe, O., Hanson, K., & Fox-Rushby, J. (2006). Some indicators of socio-economic status may not be reliable and use of indices with these data could worsen equity. *Health economics*, *15*(6), 639-644.
- Oskouei, M. M., & Fallahpour, M. (2014). Economic efficiency evaluation using Data Envelopment Analysis (DEA): Case study in cement industry. International Journal of Applied Operational Research, 4(2), 1-13.
- Pareek, P., & Sankhla, V. S. (2021). Review on vertical roller mill in cement industry & its performance parameters. *Materials Today: Proceedings*, *44*, 4621-4627.
- Paswan, R. K. (2021). Analysis of Leverage and Profitability of Indian Cement Industry. *Pacific Business Review International*, *14*(6).
- Pagell, M., Wu, Z., 2009. Building a more complete theory of sustainable supply chain management using case studies of 10 exemplars. J. Supply Chain Manage. 45 (2), 37–56.

- Pandey, A. (2017). Importance of cement industry in India. *International Journal of Marketing and Technology*, *7*(8), 29-51.
- Pandey, P., & Pandey, M. M. (2021). *Research methodology tools and techniques*. Bridge Center.
- Parhyar, A., Sethar, W. A., Malokani, D. K. A. K., Tunio, R. A., & Pathan, S. K. (2022). EFA and CFA of bureaucratic culture, Links, and entrepreneurial Satisfaction for multi-dimensional scale of entrepreneurial ecosystem. *Indian Journal of Economics and Business*, *21*(1).
- Parke, R., & Sheldon, E. B. (1973). Social statistics for public policy. In *Proceedings of the Social Statistics Section, American Statistical Association, Washington* (pp. 105-112).
- Parris, T. M., &Kates, R. W. (2003). Characterizing and measuring sustainable development. *Annual Review of environment and resources*, *28*(1), 559-586.
- Patel, R., & Singh, A. (2022). Impact of regulatory policies on socioeconomic factors in the cement industry. *Environmental Policy and Management*, 15(2), 95-110.
- Patnaik, R. (2018, March). Impact of industrialization on environment and sustainable solutions–reflections from a south Indian region. In *IOP Conference Series: Earth and Environmental Science* (Vol. 120, No. 1, p. 012016).
- Patnaik, R. (2018, March). Impact of industrialization on the environment and sustainable solutions–reflections from a south Indian region. In IOP Conference Series: Earth and Environmental Science (Vol. 120, No. 1, p. 012016).
- Poornajaf, A., Kakooei, H., Hosseini, M., Ferasati, F., & Kakaei, H. (2010). The effect of cement dust on lung function in a cement factory, Iran. *International Journal of Occupational Hygiene*, *2*(2), 74-78.
- Poudyal, L., & Adhikari, K. (2021). Environmental sustainability in cement industry: An integrated approach for green and economical cement production. *Resources, Environment and Sustainability*, *4*, 100024.
- Poudyal, L., & Adhikari, K. Resources, Environment and Sustainability.
- Rajamanickkam, M. (2016). P218 Occupational health guidelines and regulations: an overview of the indian regulatory framework, compliance and ground

realities. *Occupational and Environmental Medicine*, 73, A194 - A194. https://doi.org/10.1136/OEMED-2016-103951.534.

- Rajesh, R. (2018). 1667d Osh in india: challenges and opportunities. *Occupational and Environmental Medicine*, 75. https://doi.org/10.1136/OEMED-2018-ICOHABSTRACTS.863.
- Rampuri, S. (2017). Study and analysis of occupational & health diseases in cement industries. *International Journal for Advance Research and Development*, *2*(3).
- Rasmi, S. A. B., & Türkay, M. (2023). Sustainability analysis of cement supply chains considering economic, environmental and social effects. *Cleaner Logistics and Supply Chain*, *8*, 100112.
- Rauf, A. U., Mallongi, A., Daud, A., Hatta, M., Al-Madhoun, W., Amiruddin, R., & Astuti, R. D. P. (2021). Community health risk assessment of total suspended particulates near a cement plant in Maros Regency, Indonesia. *Journal of Health Pollution*, *11*(30), 210616.
- Rauniyar, G., &Kanbur, R. (2010). Inclusive growth and inclusive development: A review and synthesis of Asian Development Bank literature. Journal of the Asia Pacific Economy, 15, 455–469.
- Ravindra L (2021). CEMENT INDUSTRY IN INDIA: PRODUCTION & CONSUMPTION A global journal of social science, 2(1), 2581-5830.
- Ren, M., Ma, T., Fang, C., Liu, X., Guo, C., Zhang, S., ... & Huang, C. (2023). Negative emission technology is key to decarbonizing China's cement industry. *Applied Energy*, *329*, 120254.
- Resosudarmo, B. (2002). Indonesia's Clean Air Program. *Bulletin of Indonesian Economic Studies*, 38, 343 - 365. https://doi.org/10.1080/00074910215538.
- Riccardi, R., Oggioni, G., & Toninelli, R. (2012). Efficiency analysis of world cement industry in presence of undesirable output: application of data envelopment analysis and directional distance function. *Energy Policy*, *44*, 140-152.
- Richard, E. E., Augusta Chinyere, N. A., Jeremaiah, O. S., Opara, U. C. A., Henrieta, E. M., & Ifunanya, E. D. (2016). Cement dust exposure and perturbations in some elements and lung and liver functions of cement factory workers. *Journal of toxicology*, *2016*.

- Rocha, J. H. A., Toledo Filho, R. D., & Cayo-Chileno, N. G. (2022). Sustainable alternatives to CO2 reduction in the cement industry: A short review. *Materials Today: Proceedings*, *57*, 436-439.
- Rodrigues, F. A., & Joekes, I. (2011). Cement industry: sustainability, challenges and perspectives. *Environmental Chemistry Letters*, *9*, 151-166.
- Rossiter, J. R. (2002). The C-OAR-SE procedure for scale development in marketing. *International journal of research in marketing*, *19*(4), 305-335.
- Rovira, J., Mari, M., Schuhmacher, M., Nadal, M., & Domingo, J. L. (2011). Monitoring environmental pollutants in the vicinity of a cement plant: a temporal study. *Archives of environmental contamination and toxicology*, *60*, 372-384.
- Roy, P. (2018). 877 The occupational safety & health (osh) in india: the current scenario. *Occupational and Environmental Medicine*, 75, A316 - A317. https://doi.org/10.1136/oemed-2018-icohabstracts.906.
- Sahoo, N., & Kumar, A. (2022). Review on energy conservation and emission reduction approaches for cement industry. *Environmental Development*, *44*, 100767.
- S. Puntke, M. Schneider, Effects of phosphate on clinker mineralogy and cement properties, Cement International 6 (5) (2008) 80–93
- Sadjadi, S.J., Atefeh, E., 2010. A Robust DEA Technique for Measuring the Relative Efficiency: A Case Study of Cement Industry. Sci Topics. Retrieved August 27, 2010, from /http://www.scitopics.comS.

- Sahoo, N., & Kumar, A. (2022). Review on energy conservation and emission reduction approaches for cement industry. *Environmental Development*, *44*, 100767.

- Sangwan, K. S., Bhakar, V., & Digalwar, A. K. (2019). A sustainability assessment framework for cement industry–a case study. *Benchmarking: An International Journal*, *26*(2), 470-497.
- San-Jose, L.; Retolaza, J.L.; Torres Pruñonosa, J. Efficiency in Spanish banking: A multi stakeholder approach analysis. J. Int. Finance. Mark. Inst. Money **2014**, 32, 240–255.
- Sarkis, J., Geng, Y., 2005. Green supply chain management in China: pressures, practices and performance. Int. J. Oper. Prod. Manage. 25 (5),449–468.
- Saunders, M., Lewis, P., & Thornhill, A. (2007). Research methods. Business students (4th ed., Vol. 6(3), pp. 1–268). Pearson Education Limited.

- Schneider, F. (Ed.). (2011). *Handbook on the shadow economy*. Edward Elgar Publishing.
- Schneider, M., Romer, M., Tschudin, M., & Bolio, H. (2011). Sustainable cement production—present and future. *Cement and concrete research*, *41*(7), 642-650.
- Schumacher, K., & Sathaye, J. (1999). *India's cement industry: productivity, energy efficiency and carbon emissions* (No. LBNL-41842). Ernest Orlando Lawrence Berkeley National Lab., CA (US)(US).
- Scrivener, K. L., John, V. M., & Gartner, E. M. (2018). Eco-efficient cements: Potential, economically viable solutions for a low-CO2 cement-based materials industry. UN Environment Program.
- SDG, U. (2019). Sustainable development goals. *The energy progress report.Tracking SDG*, *7*.
- Sekaran, U., & Bougie, R. (2016). Research methods for business: A skill building approach. John Wiley & Sons
- Semenova, T., & Martínez Santoyo, J. Y. (2023). Economic Strategy for Developing the Oil Industry in Mexico by Incorporating Environmental Factors. *Sustainability*, *16*(1), 36.
- Serpell, A.; Kort, J.; Vera, S. Awareness, actions, drivers and barriers of sustainable construction in Chile. Technol. Econ. Dev. Econ. **2013**, 19, 272–288.
- Sev, A. How can the construction industry contribute to sustainable development? A conceptual framework. Sustain. Dev. **2009**, 17, 161–173.
- Şeyma, K. O. Ç., & YAVUZ, E. (2022). Factor Analysis for Construct Validity: An Applied Study. *Scientific Educational Studies*, *6*(2), 239-258.
- Shafii, F.; Ali, Z.A.; Othman, M.Z. Achieving sustainable construction in the developing countries of Southeast Asia. In Proceedings of the 6th Asia-Pacific Structural Engineering and Construction Conference, Kuala Lumpur, Malaysia, 5–6 September 2006.
- Shanshal, S. A., & Al-Qazaz, H. K. (2021). Consequences of cement dust exposure on pulmonary function in cement factory workers. *American Journal of Industrial Medicine*, *64*(3), 192-197.

- Shapiro, H. (2007). Industrial policy and growth.
- Sharma, S. (2007). “Liberalisation and productivity growth: a case of Indian cement industry”, International Journal of Productivity and Quality Management, 2 (3), pp. 307-321.
- Sheikh, M., & Najar, I. A. (2018). Preliminary study on air quality of Srinagar,(J&K), India. Journal of Environmental Science Studies, 1(1), 45.
- Shen, L.Y.; Hao, J.L.; Tam, V.W.Y.; Yao, H. A checklist for assessing sustainability performance of construction projects. J. Civ. Eng. Manag. **2007**, 13, 273–281.
- Silvestre, B.S., 2015a. A hard nut to crack! Implementing supply chain sustainability in an emerging economy. J. Cleaner Prod. 96, 171–181.
- Silvestre, B.S., 2015b. Sustainable supply chain management in emerging economies: environmental turbulence: institutional voids and sustainability trajectories. Int. J. Prod. Econ. 167, 156–169.
- Singh S (2021) Ambient air quality examination of a cement industry: a case study. Mater Today: Proc 37(2):3635–3638. https://doi.org/ 10.1016/j.matpr.2020.09.782.
- Singh, N. B., & Middendorf, B. (2020). Geopolymers as an alternative to Portland cement: An overview. *Construction and Building Materials*, *237*, 117455.
- Singh, R., & Pandey, R. (2019). *Energy Consumption and Economic Efficiency in the Cement Sector: A Study of India.* Energy Policy, 128, 101-112.
- Smith, J., Anderson, R., & Thompson, L. (2020). "Disparities in Air Quality Improvement from Environmental Regulations." Journal of Environmental Policy and Management, 15(2), 123-135.
- Smith, J.S., Karwan, K.R., Markland, R.E., 2009. An empirical examination of the structural dimensions of the service recovery system. Decis. Sci. 40 (1),165–186.
- Sobolev, K.G. and Soboleva, S.V. (1996) High Performance Indigenous Cement. XXIVth World Housing Congress, Ankara, Turkey. pp. 189–202.
- Stajanča M, E. A. (2012). Environmental impacts of cement production.
- Strotman, J.K., Roth, A.V., 2002. Enterprise resource planning (ERP) competence constructs: two-stage multi-item scale development and validation. Decis. Sci.33 (4), 601–628.

- Sueyoshi, T., & Goto, M. (2011). DEA approach for unified efficiency measurement: Assessment of Japanese fossil fuel power generation. Energy Economics, 33(2), 292-303.
- Summerbell, D.L, (2016). Potential reduction of carbon emissions by performance improvement: A cement industry case study. *Journal of Cleaner Production*, *135*, 1327-1339.
- Sunkad, S. G. (2021). The Role of Industries in the Development of the Nation. *European Journal of Research Development and Sustainability*, *2*(4), 55-58.
- Sunkad, S. G. (2021). The Role of Industries in the Development of the Nation. *European Journal of Research Development and Sustainability*, *2*(4), 55-58.
- Suryahadi, A., Widyanti, W., Perwira, D., & Sumarto, S. (2003). MINIMUM WAGE POLICY AND ITS IMPACT ON EMPLOYMENT IN THE URBAN FORMAL SECTOR. *Bulletin of Indonesian Economic Studies*, 39, 29 - 50. https://doi.org/10.1080/00074910302007.
- Swamy, R.N. (2011) Designing Concrete and Concrete Structures for Sustainable Development. Sustainable Development of the Cement and Concrete Industry. Proceedings of CANMET/ACI International Symposium, Ottawa, Canada. pp. 245–255.
- Tarhan, Ö. (2021). Development of Social Justice Awareness Scale: Exploratory (EFA) and Confirmatory (CFA) Factor Analysis. *International Online Journal of Education and Teaching*, *8*(3), 1603-1622.
- Tate, W.L., Ellram, L.M., Kirchoff, J.F., 2010. Corporate social responsibility reports: a thematic analysis related to supply chain management. J. Supply Chain Manage. 46 (1), 19–44. Indicators of sustainable development: guidelines and methodologies, http://www.un.org/esa/sustdev (accessed on 15.10.14).
- Ter Bogt, H.J. (2021). Efficiency, Types of. In: Marciano, A., Ramello, G.B. (eds) Encyclopedia of Law and Economics. Springer, New York, NY. https://doi.org/10.1007/978-1-4614-7883-6_43-2
- Tone, K., Toloo, M., & Izadikhah, M. (2020). A modified slacks-based measure of efficiency in data envelopment analysis. *European Journal of Operational Research*, *287*(2), 560-571.

- Uddin, A., Ali, Y., Sabir, M., Petrillo, A., & De Felice, F. (2023). Circular economy and its implementation in cement industry: A case point in Pakistan. *Science of the Total Environment*, *898*, 165605.
- Ujoh, F., & Ujoh, F. T. (2014). Appraisal of social and health impact of a cement plant at host communities in Yandev, Nigeria. *Science Journal of Public Health*, *2*(4), 275-83.
- UNDP (2016).Focus in Inclusive Development.
- United Nations University (UNU) (2012). Inclusive wealth report: Measuring progress toward sustainability. Cambridge: Cambridge University Press
- Uratani, J. M., & Griffiths, S. (2023). A forward-looking perspective on the cement and concrete industry: Implications of growth and development in the Global South. *Energy Research & Social Science*, *97*, 102972.
- Urzua, R. (1985). The uses of demographic knowledge for policies and planning in developing countries: problems and issues. *Newsletter. International Union for the Scientific Study of Population*, 23-24, 99-120.
- Valizadeh Oghani, A., Modarres Khiyabani, F., & Fegh-Hi Farahmand, N. (2020). Data envelopment analysis technique to measure the management ability: Evidence from Iran Cement industry. *Cogent Business & Management*, *7*(1), 1801960.
- Wang, Q., Ge, Y., & Li, R. (2023). Does improving economic efficiency reduce ecological footprint? The role of financial development, renewable energy, and industrialization. *Energy & Environment*, 0958305X231183914.
- Wang, Y., Xu, M., Lv, X., Wen, Z., & Chen, C. (2023). The eco-efficiency evaluation in China's cement industry: A city-level study. *Science of the Total Environment*, *865*, 161132.
- Wang, Y., Yi, H., Tang, X., Wang, Y., An, H., & Liu, J. (2023). Historical trend and decarbonization pathway of China's cement industry: A literature review. *Science of The Total Environment*, *891*, 164580.
- Whang, S.W.; Kim, S. Balanced sustainable implementation in the construction industry: The perspective of Korean contractors. Energy Build. **2015**, 96, 76–85.
- Wheaton, B., Muthen, B., Alwin, D.F., Summers, G., 1977. Assessing reliability and stability in panel models. Sociol. Methodol. 8 (1), 84–136.

- Wheelock, D. C., & Wilson, P. (2003). Robust nonparametric estimation of efficiency and technical change in US commercial banking. *Federal Reserve Bank of St. Louis Working Paper Series*, (2003-037).
- WHO, U., & ILO, I. (2010). CBR Guidelines for community based inclusive development.
- Wildavsky, A. (1966). The political economy of efficiency: cost-benefit analysis, systems analysis, and program budgeting. *Public Administration Review*, 292-310.
- Williams, D., & Brown, S. (2021). "Effects of Minimum Wage Policies on Socioeconomic Groups." Economic Policy Journal, 37(3), 432-448.
- Wood, D.J., 1991. Corporate social performance revisited. Acad. Manage. Rev. 16(4), 691–718.
- Wooldridge, J. M. (2016). Introductory Econometrics: A Modern Approach. Nelson Education.
- Worrell, E., Price, L., Martin, N., Hendriks, C., &Meida, L. O. (2001).Carbon dioxide emissions from the global cement industry. *Annual review of energy and the environment*, *26*(1), 303-329.
- Wright, A. I., Grabsch, H. I., & Treanor, D. E. (2015). Random Spot: A web-based tool for systematic random sampling of virtual slides. *Journal of pathology informatics*, *6*(1), 8.
- Wu, C.H., Wang, H., 2004. Environmental policies in decentralized governmental systems: a blueprint for optimal governance—a China case study. In: Proceedings of ENRICH Conference 2004, June 5–6, Beijing, PR China.
- Xu, Z.M., Cheng, G.D., Chen, D.J., Paul, H.T., 2002. Economic diversity, development capacity and sustainable development of China. Ecological Economics 40, 369–378.
- Yakovleva, N., Sarkis, J., Sloan, T., 2012. Sustainable benchmarking of supply chains: the case of the food industry. Int. J. Prod. Res. 50 (5), 1297–1317.
- Yang, Z., & Fang, H. (2020). Research on green productivity of chinese real estate companies—Based on SBM-DEA and TOBIT models. *Sustainability*, *12*(8), 3122.
- Yaqub, G., Khan, A., Zishan Ahmad, M., & Irshad, U. (2021). Determination of concentration of heavy metals in fruits, vegetables, groundwater, and soil samples of the

cement industry and nearby communities and assessment of associated health risks. *Journal of Food Quality*, *2021*, 1-9.

- Yaqub, G., Khan, A., Zishan Ahmad, M., & Irshad, U. (2021). Determination of concentration of heavy metals in fruits, vegetables, groundwater, and soil samples of the cement industry and nearby communities and assessment of associated health risks. *Journal of Food Quality*, *2021*, 1-9.
- Yeung, A.C.L., 2008. Strategic supply management, quality initiatives, and organizational performance. J. Oper. Manage. 26 (4), 490–502.
- Yin, X., Wu, Z., Weng, L., Xu, X., Zhou, Y., & Liu, Q. (2024). A microstructure-based model for quantifying irreversible yield stress evolution in cement-based pastes during hydration. *Cement and Concrete Research*, *180*, 107503.
- Yoganandan, G., & Sivasamy, G. (2015). Health and safety measures in Chettinad Cement Corporation Limited, Karur. *Bonfring International Journal of Data Mining*, *5*(1), 6-9.
- Yusuf, Y., Gunasekaran, A., Musa, A., El-Berishy, N.M., Abubakar, T., Ambursa, H.M.,2013. The UK oil and gas supply chains: an empirical analysis of adoption of sustainable measures and performance outcomes. Int. J. Prod. Econ. 146 (2),501–514.Zhu, Q.,
- Узі, З., & Сотник, І. (2023). Economic analysis of energy efficiency of China's and India's national economies. *Mechanism of economic regulation*, (1 (99)), 11-16.
- Zainul-Abidin, N. Investigating the awareness and application of sustainable construction concept by Malaysian developers. Habitat Int. **2010**, 34, 421–426.
- Zayed, N. M., Edeh, F. O., Islam, K. M. A., Nitsenko, V., Dubovyk, T., & Doroshuk, H. (2022). An Investigation into the Effect of Knowledge Management on Employee Retention in the Telecom Sector. *Administrative Sciences*, *12*(4), 138.
- Zeleke Z, Moen B, Bratveit M (2010) Cement dust exposure and acute lung function: a cross shift study. British Medic Council Publ 10(1):19
- Zeleke, Z. K., Moen, B. E., & Bråtveit, M. (2010). Cement dust exposure and acute lung function: a cross shift study. *BMC pulmonary medicine*, *10*, 1-8.
- Zelli, Edward Elgar, 35-44.

- Zeyede Z (2011) Respiratory health among cement workers in Ethiopia. Dissertation, the University of Bergen.
- Zhang, H., Zong, R., Zhao, J., & Zhu, Y. (2008). Dramatic visible photocatalytic degradation performances due to synergetic effect of TiO2 with PANI. *Environmental science & technology*, *42*(10), 3803-3807.
- Zhang, L. Y. (2011). Is industrialization still a viable development strategy for developing countries under climate change?. *Climate Policy*, *11*(4), 1159-1176.
- Zhang, S., Worrell, E., Crijns-Graus, W., Krol, M., de Bruine, M., Geng, G.,& Cofala, J. (2016). Modeling energy efficiency to improve air quality and health effects of China's cement industry. *Applied Energy*, *184*, 574-593.
- Zhang, S., Xie, Y., Sander, R., Yue, H., & Shu, Y. (2021). Potentials of energy efficiency improvement and energy–emission–health nexus in Jing-Jin-Ji's cement industry. *Journal of Cleaner Production*, *278*, 123335.

- Zhang, S., Xie, Y., Sander, R., Yue, H., & Shu, Y. (2021). Potentials of energy efficiency improvement and energy–emission–health nexus in Jing-Jin-Ji's cement industry. *Journal of Cleaner Production*, *278*, 123335.

- Zhu, Q., Sarkis, J., Lai, K.H., 2008. Confirmation of a measurement model for green supply chain management

Appendix

Interview Schedule

Efficiency Analysis of Cement Industry in Kashmir

Mittal School of Business, Lovely Professional University,

Punjab, 144411, India.

Research Scholar

Syed Rizwana Qadri

Mittal School of Business,

Lovely Professional University

Supervisor

Dr. Mudasir Ahmad Dar

Assistant Professor,

Mittal School of Business,

Lovely Professional University

Objective 3rd: To evaluate the social efficiency of cement industry in Kashmir

Dear Respondent,

Greetings!!

I am a Ph.D. Research Scholar from Lovely Professional University, Punjab. I am conducting research on **Efficiency analysis of cement Industry in Kashmir.** The responses given by you will be kept strictly confidential, used for research purposes only and your participation will be highly appreciated. Hopefully, your valuable responses will help us come up with a better implementation of the Efficiency for cement industry. Please mark the appropriate option ('5= Strongly Agree', '4= Agree', '3= Neutral', '2= Disagree, '1=Strongly Disagree')

Thank you in advance for giving your precious time.

Best Regards!!

Syed Rizwana Qadri.

The Following questionnaire contains two sections.

I. Personnel information relevant to the study: Background of Respondent

II. Questionnaire related to cement plants and social efficiency.

Personal Information

Please provide the correct information for each of the following. All information will be used strictly for research purposes. Please put a right (√) in the block for yes responses.

1. **Name: ………………………………………… (optional)**
2. **Gender:** Male ☐ Female ☐ **Other** ☐
3. **Age:** <15 ☐ 15-25 ☐ 25-35 ☐ 35-45 ☐ 45-55 ☐ ☐ 55-65
4. **Religion: ....**
5. **Category: Gen** ☐ **SC** ☐ **ST** ☐ **OBC** ☐
6. **Designation**: …………………………
7. **On what basis your salary is paid?**
   Daily ☐ weekly ☐ Monthly ☐
8. **Monthly wages:** ....
9. **Contact**: …………………………..
10. **E-mail Id**: …………………………..
11. **Education**: illiterate ☐ Elementary school ☐ Graduate ☐ Post ☐ Graduate
12. **Job Experience**: 0 to1 years ☐ 2-3years ☐ 3-4Years ☐ above 4 years ☐
13. **Name of the plant**: ……………………………………………
14. **Do you smoke? Yes** ☐ **No** ☐ **Ex Smoker** ☐

15. Do you have any of the diseases listed below?

a) High blood pressure
b) Asthma
c) Spinal diseases
d) Depression/ anxiety
e) High cholesterol
f) Others.............
g) None

16. Do you currently have any of these symptoms of pulmonary or lung illness?

a) Shortness of breath
b) Cough that produces thick sputum or blood
c) Cough lasting longer than 3 months
d) Any other Symptom related to problems.

17. Do you have any family history of any disease?

Yes ☐ No ☐

If Yes Name.............

Objective of study:

- **To evaluate the social efficiency of cement industry in Kashmir.**

Sr. No	**Social Efficiency**	**5= SA**	**4= A**	**3= N**	**2= D**	**1= SD**
	Workers Health & Safety					
WHS1	Workplace health and safety is considered extremely important.					
WHS2	There is an active health and safety committee					
WHS3	Every one receives compulsory health and					

	safety training.					
WHS4	The training received covered the safety risks associated with work.					
WHS5	The plant puts sufficient resources into safety					
WHS6	Management and the workforce work together to tackle safety-related issues					
WHS7	Management acts only after accidents have occurred.					
WHS8	Accidents that happen here are always fully investigated.					
WHS9	Personal protection equipment (PPE) is provided by management.					
WHS10	Management monitors if PPE is used and worn properly.					
WHS11	Management Provides health insurance policies					
WHS12	Safety inspection is done on regular basis.					
WHS13	Pure drinking water facility at the workplace.					
WHS14	Availability of clean toilets at the workplace					
WHS15	Managers and supervisors express concern if safety procedures are not adhered to.					
WHS16	Employees are not encouraged to raise safety concerns.					
	Equity					
EQ1	Career advancement opportunities are distributed fairly among employees in our plant.					
EQ2	Benefits are distributed equitably among all levels of employees in our Plant.					
EQ3	The opportunities for training and skill development are provided fairly to all employees in our plant.					

EQ4	There is transparency in communication regarding decisions related to equity within our cement company.					
EQ5	There are effective mechanisms in place for employees to provide feedback on issues related to equity within our cement plant.					
EQ6	There is diverse environment in this cement plant where everyone has equal opportunities.					
EQ7	Management is hiring worker/labors from all communities.					
EQ8	HR and management of the plant are supportive towards disabled people.					
EQ9	Comfortable in discussing social & cultural background with teammates.					
EQ10	Comfortable in sharing concerns with managers and supervisors.					
EQ11	Rehabilitation packages for displaced workers.					
EQ12	Faced discrimination in workplace due to cultural background.					
EQ13	Management educates the workers regarding equity and diversity.					
EQ14	There are policies and producers to prevent and address discrimination.					
EQ15	Faced retaliation for reporting discrimination from the management.					
EQ16	The management team handles the matters					

	related to equity satisfactorily.					
EQ17	Accommodation facility is provided by the management.					
EQ18	Subsidized education facility is provided for workers children.					
EQ19	Harassments are addressed through sexual harassment cell.					
EQ20	Labors are valued and respected by the community					
	Fair Labor					
FL1	Satisfied with my salary/Wages.					
FL2	Salary/Wages provided on time.					
FL3	Receive rewards and recognition for best performance from the owner.					
FL4	Satisfied with the support from HR department.					
FL5	Get motivation from the management.					
FL6	Provident fund facility is provided by management.					
FL7	Gratuity is paid at the end of the service					
FL8	Tripartite relationship between employer, employee and union exists.					
FL9	Job security exists in the plant.					
FL10	The management involves in decision making					

	which is relevant to my department.					
FL11	work more than 7 hours in a day					
FL12.	Have less working hours in winter.					
FL13	Have more working hours in summer.					
FL14	Working overtime.					
FL15.	Get incentive for overtime work.					
FL16	Leave Management provides paid leave once in a month.					
FL17	Maternity leave of 26 months is provided.					
FL18	Menstrual leave is provided.					
FL19	Medical facilities provided by the management					
FL20	Residential facilities provided by the management					
FL21	Management team always listen grievances through Grievance Redressal cell.					

Objective 4th: To evaluate the role of government policies in the sustainability of Cement industry in Kashmir.

Dear Respondent,

Greetings!!

I am a Ph.D. Research Scholar from Lovely Professional University, Punjab. I am conducting research on **Efficiency analysis of cement Industry in Kashmir.** The responses given by you will be kept strictly confidential, used for research purposes only and your participation will be highly appreciated. Hopefully, your valuable responses will help us come up with a better implementation of the Efficiency for cement industry. Please mark the appropriate option ('5= Strongly Agree', '4= Agree', '3= Neutral', '2= Disagree, '1=Strongly Disagree')

Thank you in advance for giving your precious time.

Best Regards!!

Syed Rizwana Qadri.

The Following questionnaire contains two sections.

III. Personnel information relevant to the study: Background of Respondent

IV. Questionnaire related to Government policies (National Clean Air Programme (2019), Occupational Health & Safety (2020), and Minimum wage Policy (2019)).

Personal Information

Please provide the correct information for each of the following. All information will be used Strictly for research purposes. Please put a right (√) in the block for yes responses.

18. Name: ……………………………………………… (optional)

19. Gender: Male ☐ Female ☐

20. Age: <15 ☐ 15-20 ☐ 20-30 ☐ 30-40 ☐ Above 40 ☐

21. **Designation**: …………………………

22. **Contact**: ……………………

23. **E-mail Id**: …………………………

24. **Education**: Up to HSC ☐ Diploma ☐ Graduate ☐ Post Graduate ☐
Professional ☐ & others ☐

25. **Job Experience:** 0 to1 years ☐ 2-3years ☐ 3-4Years ☐ above 4 ☐ years

26. **Name of the plant**: ……………………………………………

Objective of study:

To evaluate the role of government policies in the sustainability of Cement industry in Kashmir.

1. Awareness of policies

	Awareness of policies	**Yes**	**No**
AP1	Are you aware of the National Clean Air Programme (NCAP) policy?		
AP2	Are you aware of occupational health and safety (OHS) policies?		
AP3	Are you aware of the minimum wage policy?		

2. Source of Awareness

	If you are aware of the policies mentioned above, please specify your primary source(s) of information.	**5= SA**	**4= A**	**3= N**	**2= D**	**1= SD**
SW1	Government websites					

SW1.1	Industry publications,					
SW1.2	Professional networks					
SW1.3	Media Coverage					
	3. Implementation of policies **3.1 NCAP**					
IP1	Plant is meeting the particulate matter concentration limit (60 μg/m^3 /Annual; 100 μg/m^3/24hr) set by the NCAP.					
IP2	Plant is adopting cleaner technologies and best practices for controlling particulate matter emission.					
IP3	Plant has installed the efficient pollution control equipment like bag filters and alternative fuels.					
IP4	Regular reporting and transparency regarding emissions data, compliance status, and progress towards targets.					
	3.2 OHS					
IP5	We provide training to workers regarding safe work environment.					
IP5.1	Proper use of personal protective equipment.					
IP5.2	Hazard Identification					
IP6	Plant prioritizes reporting and investigating incidents, accidents and near misses.					
IP7	We allocate resources for safety initiatives and involve employees in safety decision making process through safety committees.					
IP8	Organization fosters a strong safety culture in the industry.					
IP9	Organization empowers employees to report safety concerns without fear of reprisal.					

IP10	"Zero harm" objective of OHS has been effectively implemented within our industry.					
	3.3 MWP					
IP11	Organization ensures that all workers in the industry are paid at least the minimum wage mandated by law.					
IP12	Unskilled workers are paid 8000/month as per minimum wage policy (2019).					
IP13	Skilled workers are paid 12000/month as per Minimum wage policy (2019).					
IP14	Highly skilled workers are paid 14000 as per Minimum wage policy (2019).					
IP15	Organization ensures that all categories of workers including permanent, temporary and contractual workers receive wages in accordance with the MWP.					
IP16	Organization provides transparency in wage policies and practices ensuring clear communication to workers regarding their entitlements, deduction & rights under the MWP.					
	4. Policy Impact **4.1 NCAP**					
PI1	We believe the National Clean Air Programme (NCAP) positively addressed air quality concerns associated with cement manufacturing operations.					
PI2	NCAP policy has impacted the competitiveness of the cement plant.					
PI3	The NCAP policy contributed to enhancing public perception and community relations regarding the environmental impact of the industry.					
PI4	The implementation of the NCAP policy positively impact the overall air quality in areas surrounding					

	cement manufacturing plants.					
PI5	Policy facilitated collaboration and communication between regulatory agencies & cement industry stakeholders.					
PI6	The NCAP framework has facilitated constructive collaboration and communication between our cement plant and relevant regulatory authorities					
PI7	We believe that the NCAP objectives align well with the sustainability goals of our cement manufacturing business.					
PI8	NCAP policy impacted the operational costs & profitability of Industry.					
	4.2 Occupational Health & Safety (OHS)					
PI9	Implementation of OHS policy improved safety awareness and practices within the cement industry.					
PI10	Policy reduced the number of workplace accidents and injuries in cement manufacturing operations					
PI11	policy has influenced the company's safety culture and prioritization of worker well-being within the cement industry					
PI12	OHS policy facilitated the identification and mitigation of workplace hazards in cement manufacturing facilities.					
	5. Minimum Wage Policy					
PI13	The current minimum wage policy positively contributes to the overall well-being of our workforce					
PI14	The minimum wage policy has had a noticeable effect on the company's labor costs					
PI15	Higher minimum wage boosts the morale among					

	workers.					
PI16	Increase in labor cost due to minimum wage policy directly influences the price of cement.					
PI17	Reduced hiring new employees due to increased wages resulting from minimum wage policy.					
PI18	The current minimum wage policy strikes an appropriate balance between supporting workers and maintaining the competitiveness of our business.					
PI19	The current minimum wage policy strikes an appropriate balance between supporting workers and maintaining the competitiveness of our business					
PI20	Adjustments to the minimum wage policy may impact the overall profitability and sustainability of our cement industry					
PI21	Our cement plant's adherence to the minimum wage policy has contributed to fostering a more stable and satisfied workforce.					