CLIMATE CHANGE AND IT's EFFECTS ON MANUFACTURING SECTOR

Raguel Khan, Anchal Khanna, Mehak Nihalani

ABSTRACT:

This research examines the complex link between the industrial sector and climate change, evaluating the effects of extreme weather events and rising global temperatures. It seeks to understand the many ways that environmental changes impact industrial operations, with a focus on how resource constraints, weather patterns, and environmental laws affect production sustainability and efficiency. By employing case studies, statistical analysis, and sophisticated modelling, the study pinpoints the industries, regions, and production processes that are susceptible to disruptions caused by climate change. Potential disadvantages are discussed along with chances for innovation and broad adoption of green technology. The research highlights the need for collaboration among politicians, business stakeholders, and environmental activists in achieving significant change. The paper advocates for collaborative efforts to enhance manufacturing sustainability and resilience by emphasizing the links between environmental effects and industrial innovation.

The intention is to give policymakers and business leaders a road map for creating strategies that reduce risks and promote long-term development. This research offers comprehensive insights into possibilities, problems, and strategies related to manufacturing's sustainable growth and adaptation to climate change, which makes a substantial contribution to the worldwide discourse on these topics. To support educated decision-making and positive change for an environmentally conscious industrial landscape, it offers legislators, business partners, and environmentalists an invaluable resource for understanding, navigating, and addressing the profound effects of climate change on the manufacturing sector.

INTRODUCTION:

The manufacturing sector is leading the way in economic development and industrial innovation in an era of remarkable worldwide interconnection and technical development. however, because the globe struggles with the growing issues posed by climate change, the industrial sector is undergoing a paradigm shift that necessitates a thorough comprehension of its ramifications. through analysing the complicated interaction between climate change and the manufacturing industry, this research paper gives the perception of the numerous threats that environmental changes represent to the complex network of business operations. Climate change has led to a sequence of environmental changes, basically caused by human activity which includes burning fossil fuels, deforestation, and industrial pollutants. wide-ranging effects on numerous facets of civilization result from these changes, which include rising temperatures, harsh climate, growing sea levels, and changed precipitation patterns. the manufacturing sector is specifically vulnerable among them due to its emphasis on energy-intensive operations, complicated global supply networks, and resource-intensive techniques.

A significant impact on the development of global economies and society is the manufacturing sector, which includes an extensive range of sectors from electronics to automobiles. A plethora of issues encompassing both operational and strategic elements face producers as the consequences of climate change become more substantive. The business needs to adjust to a fast-changing environmental context, from supply chain

interruptions brought on by extreme weather events to the requirement for innovative and sustainable manufacturing techniques. This research aims to comprehend the intricate link between climate change and the manufacturing sector by analysing the intricate relationships between supplier networks, manufacturing processes, and overall industrial resilience. We want to offer insights that will enhance our understanding of the problems confronting the industrial sector and open the door for the creation of sustainable and climate-resilient solutions by exploring the nuances of this connection.

We will examine some of the most important facets of this win-win partnership in the pages that follow, including energy use, resource accessibility, legal frameworks, and the contribution of innovation to reducing the negative effects of climate change on manufacturing. Through a thorough study, this research hopes to contribute to the current conversation about adapting to climate change and a comprehensive strategy for sustainability in the industrial sector.

BACKGROUND:

With academics, decision-makers, and corporations all attempting to understand the complex ramifications of this urgent environmental issue, the worldwide conversation on climate change has reached a fever pitch. Liisa Rohweder's groundbreaking research highlights the seriousness of the problem, especially in Finland where a significant portion of the population views climate change as a serious environmental concern. With an imminent ecological disaster as a background, the need to balance economic expansion with the preservation of natural systems becomes increasingly important, highlighting the critical role that companies play in addressing climate change.

Lehman Brothers' observations, which draw comparisons between combating existential dangers like terrorism and nuclear proliferation, and climate change, highlight how urgent it is for organizations and governments to take proactive steps. Various industries, including utilities, oil, gas, and insurance, are deemed highly susceptible to the associated risks as the economic environment is transformed by factors such as globalization, climate change, and technological improvements. According to Lehman Brothers, successful businesses take a proactive approach to adapting, encouraging a culture of change, and making calculated investments in both people and physical resources.

Professor Forest Reinhardt of Harvard Business School emphasizes the severity of climate change by pointing to real-world examples such as increasing sea levels, fires, and storms that are getting worse. Businesses are under growing pressure to invest in renewable energy and implement ethical practices due to changing customer expectations and regulatory frameworks. Reinhardt's observations underscore the transformative imperative facing businesses in navigating a GHG-constrained world.
Andrew J Hoffman echoes the sentiment, emphasizing the inevitability of a market shift driven by climate change. As companies confront the imperative to integrate sustainable strategies into their business models, Linda Fisher, DuPont's Chief Sustainability Officer, advocates for seizing market opportunities and effectively communicating products in a carbon-constrained world.

The narrative is enriched by the reflections of Pinkse, Kolk, Boiral, Henri, Talbot, Gasbarro, Rizzi, Frey, Puppim de Oliveira, Chiappetta Jabbour, Williamson, Lynch-Wood, Ramsay, Conroy, Deller, and Tsvetkova, each offering unique insights into the evolving landscape of climate change adaptation within the manufacturing sector. From

the adoption of carbon management practices to the exploration of business strategies for reducing greenhouse gas emissions, from the impact of climate-induced physical changes on resource-intensive businesses to the role of corporate social responsibility among small and medium enterprises, the literature underscores the imperative for proactive, adaptive responses to climate change within the manufacturing sector.

In light of this, the research aims to add to the current conversation by investigating the complex interactions between climate change and the manufacturing industry, illuminating many aspects of the impacts, and proposing solutions for sustainability and resilience in the face of a more unpredictable environmental future.

LITERATURE REVIEW:

Liisa Rohweder's paper sets the stage by highlighting global concerns about climate change, particularly in Finland where 86% of the population perceives it as a serious environmental threat. The challenge of reconciling economic expansion with the impending breakdown of natural systems is underscored, emphasizing the crucial role of corporations in combating climate change.

Lehman Brothers draws parallels between addressing climate change and managing nuclear or terrorist threats. While corporations are recommended to prepare for higher probability situations, governments are urged to concentrate on minimizing severe disasters. Globalization, technology, and climate change are recognized as major forces influencing the state of the economy, with consequences for industries including utilities, gas, oil, and insurance. Proactive adaptability, a culture of change, and smart investments in people and physical resources are attributes of successful businesses.

Harvard Business School Professor Forest Reinhardt highlights the current impact of climate change with intensifying storms, fires, and rising sea levels. The urgency is emphasized as businesses respond to eco-friendly regulations, consumer demands for sustainability, and investments in renewable energy and responsible practices.

Andrew J Hoffman emphasizes that companies face an unavoidable market shift due to climate change, necessitating proactive measures. Linda Fisher, DuPont's Chief Sustainability Officer, advocates for sustainable strategies integrated into overall business plans, emphasizing the importance of seizing market opportunities, and effectively communicating products in a GHG-constrained world.

Jonatan Pinkse and Ans Kolk contribute a chapter reflecting on the increasing attention businesses have given to climate change since the 1990s, particularly with the pivotal moment of the Kyoto Protocol in 1997. The researchers explore the initial resistance of companies to international climate policies and the subsequent shift in stance as government support for such agreements grew.

Olivier Boiral's article addresses managerial challenges in responding to global warming and the Kyoto Protocol. Boiral advocates for a proactive, anticipatory approach, challenging rigid climate change strategies, and highlighting the need for dynamic responses. Specific actions managers can take to incorporate the Kyoto Protocol into their agendas are illuminated, promoting flexibility and adaptability in the face of climate change challenges.

Su-Yol Lee and Robert D. Klassen have explored the adoption of carbon management practices (CMPs) in response to global warming. They attribute variations in firms' reactions to external business uncertainty and internal organizational capabilities. Their findings underscore the pivotal role of organizational capabilities, particularly organizational learning, and lean production capabilities, in facilitating CMP adoption and implementation. Lean production capability emerges as a positive moderator, mitigating the impact of business uncertainty on CMP adoption.

Olivier Boiral, Jean-François Henri, and David Talbot contribute a framework to understanding business strategies for reducing greenhouse gas emissions. Their research challenges the presumed trade-off between environmental commitment and economic motivations, revealing a win-win association between reducing emissions and financial performance.

Federica Gasbarro, Francesco Rizzi, and Marco Frey delve into the impact of climate change-induced physical changes on resource-intensive businesses, specifically energy and water companies. Using data from the Carbon Disclosure Project, they uncover companies' proactive measures to address challenges posed by extreme weather events, droughts, and water scarcity. This research not only highlights adaptive strategies but also underscores the role of innovation in steering climate-related challenges and opportunities.

In the realm of corporate social responsibility (CSR) among small and medium enterprises (SMEs) in developing countries, Jose A. Puppim de Oliveira and Charbel Jose Chiappetta Jabbour showcase a comprehensive conceptual framework. Focusing on industrial clusters, their study identifies three cluster governance types—legal enforcement, supply chain pressure, and voluntary CSR engagement. This framework reveals varied responses in CSR stages, environmental practices, and climate change strategies within SME clusters.

David Williamson, Gary Lynch-Wood, and John Ramsay shift the focus to environmental practices in manufacturing SMEs. They find that business performance and regulatory considerations predominantly shape behaviour. Additionally, the study questions the effectiveness of CSR policies, advocating for reliance on existing regulatory structures to induce meaningful behavioural changes in manufacturing SMEs.

Tessa Conroy, Steven Deller, and Alexandra Tsvetkova explore interstate relocations among manufacturers using the National Establishment Time Series database. Their analysis emphasizes disparities in the business climate between origin and destination states, revealing that only a small proportion of manufacturing firms relocate across state lines. Furthermore, the research suggests limited success in attracting manufacturing firms through traditional approaches to business climate improvement.

THE RATIONALE OF THE STUDY:

1) Challenges Faced by Manufacturing Businesses:

Understanding the difficulties faced by manufacturing companies is essential to comprehending the dynamics of the sector. These challenges cover a wide variety of problems that affect manufacturing companies' capacity to operate sustainably and efficiently.

Decarbonization and Sustainability:

Manufacturing organizations struggle to meet the demands of both sustainability and decarbonization. Complying with international environmental targets entails lowering carbon footprints, guaranteeing climatic neutrality, and adopting eco-friendly behaviours.

Growing Energy Costs:

The increasing cost of energy is one major obstacle. Energy-intensive manufacturing processes result in significant cost burdens from changes in energy prices. Creating solutions that work requires an understanding of how these expenses affect operations.

Volatile Supply Chains:

Manufacturing companies are vulnerable to supply chain interruptions caused by geopolitical crises, natural calamities, or other unexpected incidences. This instability needs measures for developing robust and adaptable supply chain networks.

2) Strategies Used by Manufacturing Businesses to Overcome Climate Change:

Examining the strategies employed by manufacturing businesses to address climate change is integral to comprehending their commitment to environmental responsibility and resilience.

A key tactic is to adopt a circular economy perspective:

This comprises reevaluating manufacturing methods to reduce waste, boost recycling, and promote sustainability, eventually helping to reverse the effects of climate change.

Adoption of Low Carbon Production Processes:

Businesses are developing plans to transition to low-carbon or carbon-neutral industrial processes. This includes disclosing a company's carbon footprint and implementing technology that lessens environmental effects.

Improving resource efficiency in industrial processes is a key tactic:

This includes not only lowering greenhouse gas emissions but also improving overall resource management.

RESEARCH OBJECTIVE:

1) Challenges Faced by Manufacturing Sectors:

Insufficient Skilled Labour:

For the industrial sector, a persistent concern is the lack of competent labour. This problem affects industrial companies of all sizes, having an impact on overall production and efficiency. Businesses find it difficult to satisfy production goals and adjust to technological developments in manufacturing processes when they lack qualified staff.

Provider Issues:

Problems in the supply chain are typically the root cause of manufacturing troubles. Unreliable suppliers may cause manufacturing process interruptions, delays, and higher expenses. To lessen these difficulties, businesses must have strong connections with their suppliers and backup plans.

Changing Market circumstances:

Manufacturing organisations face difficulties due to fluctuating market circumstances, which include changes in client needs and unpredictability in the global economy. To be competitive, one must be nimble and strategically prepared to adjust to these changes.

2) Strategies by Manufacturing Businesses to Overcome Climate Change:

Manufacturing businesses are increasingly recognizing the need to combat climate change. while the available search results did not expressly describe strategies, common practices include:

Adopting Sustainable techniques:

Manufacturers are incorporating sustainable and eco-friendly techniques into their operations, lowering carbon footprints, and minimizing environmental effects.

Investing in green technology:

The use of power-efficient technology and renewable energy resources can help manufacturing companies reduce their dependency on fossil fuels and lower greenhouse gas emissions.

circular economy:

Circular economy practices encompass reducing waste, reusing materials, and recycling. This enables to increase in resource efficiency and reduces the environmental effect of manufacturing operations.

RESEARCH METHODOLOGY:

This paper provides a qualitative study based on records extracted and analysed from crucial government files like "Assessment of Climate Change over the Indian Region" and research papers. First, we have tried to express that climate Change is briefly supported by facts and figures. Further, we have given context.to the pillars that make up the economy and how they have been suffering accordingly from climate change. We've emphasized rising temperature, its impact on mitigation, Heat waves, economic impacts, impact on the natural environment, Climate Risks in India's Manufacturing Landscape, measuring CGC emissions, Covid-19 effect. Then we discussed manufacturing strategies that are essential to development and how they help overcome difficult situations. Even while keeping a check on climate change with valuable suggestions.

DISCUSSION:

High temperatures affect output.

Heatwave days are increasing due to temperature rise brought on by global warming. With over 600 deaths each year from weather-related causes in the US, extreme heat is already the leading culprit. The effect is also felt in global production centres, where buildings without climate control depend on the outside weather. In China and other nations where temperatures are rising, a single day over 90 degrees Celsius in 2017 lost a factory $10,000 in production. Heat-related production losses might exceed $47 billion by 2050, which would be a serious challenge to nations like China that rely largely on manufacturing. High temperatures not only cause financial losses but also endanger worker safety, emphasizing the need to strike a balance between production and protecting workers' health in the face of rising temperatures.

Severe weather puts businesses at risk

Climate change is increasing the frequency and severity of extreme weather occurrences throughout the planet, including powerful storms, severe droughts, uncontrolled wildfires, and abnormally frigid winters. These

occurrences represent considerable threats to enterprises, depending on their geographic location. For manufacturing facilities in northern regions, blizzards can impede work by making transportation and operations impossible. In temperate zones, hurricanes can cause prolonged power outages, disrupting productivity. To adapt to these challenges, businesses can take proactive measures such as using jobsite heaters in cold climates, employing blankets for concrete curing in winter, and implementing backup power solutions like generators and solar panels for areas prone to hurricanes. Even industrial centres face the threat of wildfires, emphasizing the need for businesses to be prepared and adaptable in the face of evolving climate-related risks.

High Temperatures Damage Sensitive Components

High temperatures pose a threat to electronics and sensitive components used in manufacturing, affecting both low-tech and high-tech industries. The impact is not limited to warm climates, as temperature sensitivity becomes a critical concern for the technology-driven manufacturing sector. To address this issue, business owners are urged to invest in interior climate control for their facilities, considering the potential dangers of rising temperatures on human workers. Many manufacturing facilities lack proper insulation, experiencing extreme temperatures in different seasons. Balancing investments in climate control becomes essential for ensuring the safety of workers and fostering the growth of the manufacturing industry.

Covid-19 Effect

As we go into the 2020s, the equipment industry is set for a significant shift driven by three interconnected trends: the economics of technology, growing investor expectations, and regulatory actions. One of the game-changers is the rapid advancement of technology, particularly the move towards electrification. Together with energy-efficient electric motors and the industrial Internet of things, wind, and solar energy are becoming commercially viable options as well as ecologically responsible ones. This change is forcing the traditional fossil fuel-powered machinery to be replaced. Furthermore, it's expected that technologies like carbon capture, utilization, and storage (CCUS) and the "green hydrogen value chain" will be increasingly important in the industry's attempts to decarbonize and attract more investment in the upcoming ten years.

Another factor influencing the equipment business is investor pressure. When making investment decisions, many asset managers—including industry giants like BlackRock—are considering carbon pricing. Giants in the equipment industry like Bosch and Siemens have been impacted by this scrutiny and have set aggressive targets for reducing carbon emissions as a result of investors' rising emphasis on sustainability.

The impacts of these disruptions will vary across end markets, depending on machinery makers' exposure to Scope 1 emissions and their ability to withstand stakeholder demands and the impacts of global warming. In essence, the machinery industry is entering a challenging period of transformation shaped by technological shifts, investor expectations, and regulatory developments.

Measuring GCG Emissions

The equipment business is experiencing considerable transformations as a result of three primary trends: changes in technological economics, increased investor pressure, and regulatory initiatives. With the worldwide push for decarbonization, these developments are not only changing the way machinery makers do business but also impacting how they design their goods.

One significant effect of the global shift away from fossil fuels is anticipated, particularly in the transportation sector. Peak crude oil demand is anticipated in 2030, which would cause disruptions to the whole oil industry's value chain, including equipment required for extraction and processing. Manufacturers of machinery are thus being forced to reconsider their product ranges and supply chains.

Sustainable equipment platforms are becoming more and more important to customers who want to meet aggressive decarbonisation targets in the 2020s. Efficiency, adaptability, and recyclable materials are increasingly important considerations when making purchases. To maintain their competitiveness in the market, machinery makers are therefore adjusting to these changing demands.

The industry is also witnessing the emergence of new participation models and choices, akin to what has been happening in the automotive sector. This involves strategic decisions about adopting new technologies, investing in services, and leveraging IoT and data. Such choices play a crucial role in shaping the future of the machinery sector.

As new technologies emerge, business models are also changing. For example, the shift from traditional gas turbines to wind turbines requires a different approach to value capture. Companies are navigating this change by moving from a focus on replacement parts to providing initial sales, ancillary services, and software tools. Flexibility in business models is becoming crucial to adapt to evolving customer needs and technological advancements.

The machinery industry is facing increased pressure from stakeholders, including investors, customers, and employees, to contribute to emission reductions. Many companies are committing to becoming carbon neutral, involving the adoption of cleaner energy sources, more efficient machinery, and exploring carbon offset options.

Circular value chains are gaining prominence, with customers emphasizing a machine's total emissions footprint throughout its life cycle (Scope 3 emissions). There's a rising demand for machines made with greener materials and designed for recyclability or repurposing. Manufacturers need to align their design priorities and business models with the circular economy, incorporating sustainable practices in material selection and end-of-life considerations.

Climate change is impacting the operations of machinery businesses, posing risks to plants, supply chains, and service operations. The increasing frequency of weather-related events requires a reassessment of environmental assumptions in service contracts and warranties. Machinery makers are working towards enhancing resilience against weather, sea-level, and operational risks to ensure business continuity in the face of these challenges.

Navigating Climate Risks in India's Manufacturing Landscape

In India, efforts like Make in India and Production-Linked Incentive schemes have been set in motion to boost local manufacturing and foster economic growth. The government, both at the central and state levels, has rolled out supportive policies, including the establishment of industrial clusters and mega parks. Despite these positive steps, the manufacturing sector is grappling with significant climate risks that pose substantial challenges.

These climate risks come in two main forms. First, there are physical risks that can cause damage to assets and disrupt value chains. This includes the potential impact of extreme weather events on manufacturing facilities and transportation networks. Second, there are risks associated with the transition to a low-carbon economy and advancements in technology. Adapting to new environmental standards and staying current with innovations is crucial for manufacturers to thrive in this evolving landscape.

The failure of firms to adapt to climate change has been identified as the second global risk with severe consequences, according to the World Economic Forum in 2023. Industries with low adaptive capacities, particularly in manufacturing, face heightened vulnerability. This vulnerability poses a critical threat to India's journey towards a more sustainable future.

Key sectors like pharmaceuticals, chemicals, and automobiles, which contribute significantly to employment and Gross Value Add, are susceptible to potential disruptions in their production processes. This, in turn, could impact their financial health. Additionally, supply chains are under threat, with transportation, housing, and healthcare facilities facing increased risks due to climate hazards.

Even though the pharmaceutical and chemical industries have a global competitive edge, the automobile sector is anticipated to play a pivotal role in India's manufacturing growth, especially with the accelerated focus on electric mobility. The challenges posed by climate risks underscore the importance of proactive measures and adaptability within the manufacturing sector to ensure a resilient and sustainable future for India's industries.

The importance of the pharmaceutical, chemical, and automobile sectors in India highlights the need to carefully assess climate risks at the district and industrial cluster levels. According to the Global Climate Risk Index 2021, India ranks seventh in climate vulnerability, considering the impact of extreme weather events and global warming. The country faces diverse risks, including riverine and coastal flooding, exposure to cyclones, and susceptibility to drought.

WRI India's geo-analytics, through spatial data analysis, reveal that climate hazards vary depending on the geographical location. Coastal states are vulnerable to rising sea levels, lightning, and cyclones, while hill states face risks of landslides and flash floods. Many regions, including highly industrialized states like Maharashtra, Tamil Nadu, Karnataka, Gujarat, and Telangana, are susceptible to multiple risks such as extreme heat, drought, water stress, and groundwater depletion. Assessing these risks at the district and cluster levels becomes crucial to understanding and mitigating potential impacts, especially on key sectors.

Examining the state of the pharmaceutical, chemical, and automobile sectors in India using the Annual Survey of Industries (ASI) frame data for 2019-20, with a focus on formal sector jobs, reveals that around 20% of India's economy is within the formal sector, as per Reserve Bank of India (RBI) statistics.

The pharmaceutical industry's concentration has increased over the years, with Telangana, Maharashtra, Andhra Pradesh, and Gujarat being dominant in terms of output, factories, and employment, contributing to over 50% of pharma-associated metrics. Districts like Ahmedabad, Pune, Bangalore, Visakhapatnam, Hyderabad, and Rangareddy show higher concentrations of pharma employment within these states.

Similarly, chemical sector establishments cluster in Surat, Mumbai-Raigad, Haridwar, and Virudhunagar, while the automobile sector is concentrated around Pune-Mumbai-Nashik, Aurangabad, Chennai, Kanchipuram, Gurgaon, and Faridabad.

Clusters in the eastern regions (Chennai, Kanchipuram, Visakhapatnam, East Singhbhum) are prone to extreme precipitation, water stress, lightning strikes, and heat waves. Western clusters (Pune, Bharuch, Raigad) face risks of extreme precipitation, heat stress, meteorological drought, and earthquakes. The Haridwar cluster is prone to earthquakes, lightning strikes, heat waves, and water stress. The Solan cluster faces cold waves, landslides, water stress, and earthquakes. Air quality-related risks impact clusters across these sectors.

Given the increasing frequency and intensity of climate hazards with varying impacts, spatial analysis of climate vulnerabilities is crucial for devising localized measures to enhance the resilience of industrial clusters in India.

Impact on the natural environment

Temperature and weather changes

India's average annual temperature increased by 1.3 degrees Fahrenheit throughout the course of the 20th and early 21st centuries.

1. An extreme heatwave that peaked in May 2022 in Pakistan and India saw temperatures as high as 123.8 °F.
2. Similar heatwaves to the one that occurred in 2010 are now predicted to occur every three years as opposed to the previous expectation of every 312 years.

3. It is anticipated that in the upcoming decades, there will be more droughts in Northern and Northwestern India. By the end of the century, it's possible that the majority of India may experience increasingly severe droughts.
4. There's a chance that floods and landslides will happen more frequently and intensely in Assam and other states.

Sea level rise and water resources:

Meghalaya and other northeastern Indian states are concerned about what rising sea levels may mean for Bangladesh and particularly about the likelihood of a refugee catastrophe. according to climate change projections, increasing sea levels might cause Bangladesh and nearby areas of India to lose a large quantity of their coastal lands. in the Sundarbans, where low-lying islands were inundated because of ongoing sea level rise, hundreds of humans have already been forced to flee. rising temperatures at the Tibetan Plateau are forcing the Himalayan glaciers to recede. this might have an impact at the flow rate of important rivers like the Yamuna, Brahmaputra, and Ganges, which can be essential to the lives of many farmers. A report released in 2007 by the Worldwide Fund for Nature (WWF) suggests that the Indus River may eventually dry up due to the same phenomenon.

Ecosystems:

Additionally, it is predicted that ecological disasters will occur more frequently. In 1998, for example, a coral bleaching event caused by rising ocean temperatures linked to global warming killed out almost 70% of the corals in the reef ecosystems off Lakshadweep and the Andamans.

Economic impacts

India is the country with the finest global carbon social price. In 2040, the poverty rate in India may rise by 3.5%, and the country's GDP ought to decline by 3–10% annually as a result of climate change, according to a study released via the International Think Tank Overseas Development Institute in London.

Reduced crop yields:

The lives of over 400 million humans in poverty in India are at significant risk because of the effect of climate change. these people closely depend on natural resources for his or her basic needs, which include meals, shelter, and income. A radical study performed by using the national innovations in climate Resilient Agriculture (NICRA) has delved into the repercussions of climate change on agriculture in India.

The study shows that the results will no longer spare even the vital rice crops. Rainfed rice yields are expected to see a moderate decrease of under 2.5% by the years 2050 and 2080. however, the situation is more alarming for irrigated rice, as yields are projected to decline by 7% in 2050 and a staggering 10% in 2080. This paints a concerning picture for the future, specifically for the ones already grappling with poverty and dependency on agriculture for their livelihoods.

Health impacts:

Since 1970, counteracting the consequences of climate change have included actions such as irrigation, which cools the air through evaporation, and air pollution, which reflects sunlight. It requires some careful balance, though. They not only mitigate the effects of climate change but also increase the intensity of heat waves, which raises the death toll. Therefore, these elements are like a double-edged sword—they contribute to both the exacerbation and mitigation of many parts of our environmental concerns.

Impacts on Migration

The impending danger posed by climate change affects India directly as well, particularly in major cities like Chennai and Mumbai. Seven million people will be left behind at home if global temperatures increase by two degrees Celsius, and large portions of these densely populated cities will flood. There is an urgent need for climate action because of the possible devastating effects.

By 2050, when an estimated 45 million people may have to leave their homes due to natural calamities brought on by climate change, India expects a significant increase in displacement connected to climate change. This is a worrying figure since it is more than three times the number of individuals who have been moved before because of bad weather. According to the "State of India's Environment-2022" study, India is the fourth most affected nation in terms of migration brought on by climate change, which presents a concerning image. In 2020–2021, almost three million individuals were compelled to flee their homes, illustrating the increasing influence of climate change on the nation's migratory trends.

The effects reach communities in Meghalaya, a northeastern state of India, in addition to metropolitan regions. Here, worries about the possible effects of increasing sea levels in Bangladesh, a neighbour, are intensifying in addition to those regarding local villages. The villagers worry that this would trigger a wave of migrants into Meghalaya, a state with no means to deal with such a crisis. It serves as a sad reminder that the repercussions of climate change affect people worldwide and cut beyond national boundaries. Coordinated efforts to fight climate change are more important than ever.

Facts showcasing the effect of the manufacturing industry on Climate change in India.

1. **2% Revenue Loss:** For every one-degree rise in annual temperature, plants produce about 2% less revenue.
2. **GDP Impact:** The Reserve Bank of India (RBI) estimates up to 4.5% of India's GDP could be at risk by 2030, due to lost labour hours from extreme heat and humidity.
3. **Job Losses:** India may account for 34 million of the projected 80 million global job losses from heat stress-associated productivity decline by 203.
4. **Climate-Related Events Cost:** In 2019 alone, India lost nearly $69 billion due to climate-related events.
5. **Increased Operational Costs:** In the industrial sector, there could be an increase in operational costs reducing profitability, owing to the imposition of new climate-friendly regulations, reduced utilization of old stock of capital, and diversion of investment towards greener infrastructure/capital/technology.
6. **Heat Stress on Workers:** Research shows that it gets harder for people to work when it gets hot, leading to a reduction in national output in warmer years. This is reflected in lower Indian GDP output in hot years and possibly also lower year-on-year growth.
7. **Climate Control in Workplace:** Climate control in the workplace removes productivity declines but not absenteeism, presumably because workers remain exposed to high temperatures at home and outside.
8. **Limited Adoption of Climate Control:** The limited adoption of climate control technologies in manufacturing industries compounds the problem of heat stress on workers.
9. **Potential Increase in Automation:** The industrial sector might respond to high temperatures by increasing automation and shifting away from labour-intensive sectors in hot parts of the world.

STRATEGIES:

safeguarding future manufacturing

The impact of climate change is already substantial, with rising temperatures and an increase in the frequency of extreme weather events anticipated despite attempts to cut global carbon emissions. The industrial industry is very weak. Even though it can be difficult to stop climate change from having an impact on industry, company owners can proactively address these problems by making the appropriate modifications.

Recent studies have highlighted the relationship between warmer temperatures and reduced economic output in developing countries, emphasizing the impact on worker productivity and increased absenteeism during scorching days. The researchers studied a high-frequency microdata set of worker output and a dataset covering more than 58,000 factories in India. Their findings show that for every one-degree increase in annual temperature, the

revenue of manufacturing plants drops by a significant 2%. This decline in income is not limited to the factory floor; It ripples through the wider economy, potentially affecting India's GDP growth.

Study co-author and South Asia director of the Energy Policy Institute at the University of Chicago, Dr. Anant Sudarshan pointed out that the most pronounced decline is in labour-intensive plants, which raises concerns for a country like India. To become a manufacturing hub dependent on affordable labour. The research goes beyond the known impact of higher temperatures on crop yields, showing how a warming world can constrain economic output by affecting human labour productivity.

The study highlights that the harmful effects are most pronounced when already warm days become even warmer. Dr. Sudarshan emphasizes that there is an urgent need for India to adapt to this changing climate, especially concerning its manufacturing sector aspirations. The research, conducted in collaboration with experts such as E. Somanathan, Rohini Somanathan, and Meenu Tewari, highlights that the implications extend beyond manufacturing to any sector heavily dependent on labour.

While the study suggests that implementing climate control in the workplace helps somewhat, it does not fully address absenteeism, as workers are still exposed to high temperatures indoors and outdoors. Additionally, the high cost of such climate control measures limits their widespread adoption in manufacturing industries.

Looking ahead, the study points to concerns about possible responses to higher temperatures in the industrial sector, such as increased automation and a move away from labour-intensive sectors to warmer regions. These adaptations, while addressing productivity issues, may worsen wage inequality. Dr. Sudarshan expresses concern about a potential 'heat tax' affecting the hotter countries of the developing world, damaging the competitiveness of their manufacturing sectors, and affecting the wages of poor workers.

Considering these findings, the researchers advocate for further research into low-cost techniques to protect workers from ambient temperatures. They believe that such technologies have significant social value, helping to mitigate the adverse economic and social impacts of rising temperatures on the manufacturing sector and labour force in developing countries.

Climate change is posing severe problems to the engineering sector because of the increased demand for more ecologically friendly items like air conditioners and mining equipment. Both directly and indirectly, these devices are a part of industrial processes that have a major impact on greenhouse gas emissions. Machine makers are battling three main issues as public concern over global warming grows: the requirement for commercially viable green technology, more stringent laws, and rising investor demands for the adoption of climate-friendly practices.

Machine manufacturers are finding themselves in a situation where they must reconsider their conventional methods of operation as the need to address climate change becomes more pressing. This entails altering their entire business strategy in addition to the product design. While those who fall behind may run the risk of becoming outdated in the field, those who can rise to these difficulties will have the chance to investigate new avenues. The worldwide commitment to achieve a net-zero carbon world—a goal made increasingly more obvious by the challenges posed by the COVID-19 pandemic—underlines the urgency of this transformation.

Despite previous difficulties in meeting carbon reduction targets, it is becoming increasingly clear that addressing climate change is not only an environmental imperative but also a critical aspect of ensuring the long-term sustainability of businesses. Companies that can proactively respond to these challenges not only join global environmental goals but also position themselves for success in a changing and conscientious marketplace.

Proactive Strategies for Machinery Manufacturers

Machinery makers are advised to adopt the following proactive measures as we negotiate the difficulties of the 2020s to ensure their place in a constantly shifting landscape:

1. **Mapping the Course for an Eco-Friendlier Future:** Industry leaders should examine their present operations and markets more closely in light of impending changes. It is possible to pinpoint possibilities for expansion by imagining various scenarios for the ensuing ten years, which can include modifications to end markets, shifting consumer expectations and unpredictability in regulations. This might entail creating digital services companies, breaking into the green machinery market, and creating new technologies. By 2050, machinery makers are expected to generate a substantial $12 trillion in revenue in this sector of the economy.

2. **Embracing Sustainability:**

To meet evolving customer expectations, machine manufacturers should prioritize sustainable design principles. This means emphasizing efficiency, recyclability, and minimizing the impact on the environment when developing products. Adapting to a circular economy and incorporating green practices into material selection are critical steps to ensure long-term success.

3. **Adapting Business Models:**
The push for decarbonization necessitates a re-evaluation of traditional business models. Companies should explore innovative options such as offering digital services, entering the emerging green segment, and keeping up with changing customer demands. Flexibility and a willingness to innovate business models will be key to successfully navigating the disruptions of the 2020s.
4. **Increasing Operational Resilience:**

Manufacturers of machinery must make their operations more resilient to weather-related disasters as climate change has an ever-growing effect on daily operations. This entails updating operational plans, warranties, and contracts' environmental presumptions to guarantee company continuity in the case of unforeseen difficulties. All things considered, the engineering sector is at a critical turning point due to the pressing need to reduce carbon emissions. In addition to being necessary survival tactics, adjusting to changing consumer expectations, implementing sustainable practices, investigating new business models, and bolstering operational resilience are all essential measures to guarantee long-term success in a quickly changing market.

CONCLUSION:

Navigating the intricate link between climate change and the manufacturing sector, this study illuminates the diverse implications of the environmental challenge. The global conversation on climate change, as evidenced by scholars such as Liisa Rohweder, Lehman Brothers, Forest Reinhardt, and others, underscores the pressing need for proactive measures in the face of a transformative imperative for businesses.

The manufacturing sector, vulnerable to climate-induced risks, must reconcile economic growth with environmental preservation. Observations from experts highlight industry vulnerabilities, especially in sectors like utilities, oil, gas, and insurance. Lehman Brothers' emphasis on proactive adaptation, cultivating a culture of change, and strategic investments in physical and human capital is crucial for success. The inevitability of a market

shift towards sustainability, noted by Andrew J Hoffman and Linda Fisher, emphasizes the integration of responsible practices into business models. This literature presents diverse perspectives, from carbon management to corporate social responsibility, emphasizing the imperative for adaptive responses in the manufacturing sector.

As businesses grapple with climate change challenges, this research contributes to the discourse by providing a comprehensive examination of the nuanced interplay between climate change and manufacturing.

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