# Green Hydrogen : A Sustainable Solution to Global Energy and Climate Challenges

**- DP Misra**
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DP Misra completed his graduation in Chemical Engineering from Jadavpur University in 1965. With a distinguished career spanning several decades, he served as the Deputy Managing Director at Jacobs Engineering India and as the Managing Director of BPMEL, a Government of India undertaking. He also held the position of Director at Tata Consulting Engineers.

His contributions to the chemical engineering profession are recognized through his leadership as the former President of the Indian Institute of Chemical Engineers (IIChE) and his role as the Director General of the Indian Chemical Council (ICC). His achievements in the field have earned him prestigious accolades, including the Lifetime Achievement Award from both the Indian Chemical Council and the Indian Institute of Chemical Engineers.

## Introduction

The world is undergoing a significant shift in its approach to energy, transitioning from fossil fuels to renewable sources, and increasingly looking towards non-fossil fuel alternatives like hydrogen. Traditionally associated with industries such as food processing—like in hydrogenated vegetable oils (Dalda)—hydrogen is now being hailed as a game-changing energy carrier in the fight against global warming and climate change. The United Nations Framework Convention on Climate Change (UNFCCC) and global climate change meetings such as COP (Conference of the Parties) play a pivotal role in shaping policies to address these environmental concerns. These decisions are crucial as the world faces the impending impacts of a 4°C rise in global temperatures compared to pre-industrial levels.

## The Impact of Climate Change

According to UNFCCC predictions, a 4°C rise in global temperatures would result in catastrophic consequences, including:

- Unprecedented heatwaves
- Severe droughts and flooding
- Inundation of coastal cities
- Increased risks to food production, potentially leading to malnutrition
- Water scarcity and increased frequency of high-intensity tropical cyclones
- Irreversible loss of biodiversity, including coral reefs

The present temperature of the Earth is already 0.8°C higher than pre-industrial levels, and the goal set during the Paris Agreement is to limit the increase to no more than 2°C. The consequences of continued global warming are dire, and the need for sustainable solutions has never been greater.

## Present Status of Global Warming

The concentration of carbon dioxide (CO2) in the atmosphere continues to increase, surpassing 391 PPM (parts per million) as of 2012. This rise is mainly due to emissions from fossil fuels. Along with the increasing CO2 levels, global oceans are warming, trapping excess heat, and ice loss in the Arctic has accelerated. Sea levels have risen by about 15-20 cm in the 20th century, and the rate of increase continues at 3.2 cm per decade, with a potential additional rise of 30 cm by the end of this century. Coastal cities such as Shanghai, Mumbai, and Kolkata are at risk of submergence.

Furthermore, there has been a dramatic

increase in the frequency of heatwaves, and large nations such as Mexico, India, and Indonesia are increasingly vulnerable to floods, economic losses, and climate-related disasters.

**India's Action Plan for Climate Change**

India, acknowledging the growing challenge of climate change, launched the National Action Plan on Climate Change in 2008. The plan aims to address climate change while promoting sustainable development. Various national missions have been initiated, including:

1. National Mission for Enhanced Energy Efficiency
2. National Solar Mission
3. National Electric Mobility Mission
4. National Smart Grid Mission
5. National Mission on Advanced Ultra Super Critical Technology
6. National Mission on Transformative Mobility & Battery Storage

India has also made significant progress in renewable energy deployment, with 100 GW of grid-connected renewable capacity achieved in 2025. The country's target is to achieve 450 GW by 2030.

**Hydrogen: A Key to a Sustainable Energy for Future**

Hydrogen, an abundant and non-polluting fuel, offers significant potential in decarbonizing various sectors. It is produced using a variety of methods, including steam methane reforming (SMR) using natural gas, coal gasification, biomass gasification, and electrolysis. However, the current focus is shifting toward “green hydrogen,” produced using renewable energy sources like wind and solar power, which can reduce CO2 emissions significantly.

Hydrogen's applications are diverse, from fuel cell vehicles to electricity generation and the production of chemicals and fertilizers. Its most significant advantage is the zero-emission nature of its use, especially when green hydrogen is utilized.

**Hydrogen Production and Technologies**

Hydrogen can be produced using a range of technologies, including:

1. Steam Methane Reforming (SMR): The major plants in India currently use this process. This method uses natural gas or naphtha to produce hydrogen and is currently the most common method.
2. Partial Oxidation Using Heavy Fuel Oil: Another method for hydrogen production..This process is utilized in RCF Mumbai
3. Coal Gasification: Used in plants such as those at Angul and Talcher, Odisha, for fertilizer production.
4. Biomass Gasification and Pyrolysis: Utilizes organic materials for hydrogen production.
5. Water Electrolysis: A cleaner process, with plants such as those in Rourkela, Odisha, using electricity to split water into hydrogen and oxygen.
6. Byproducts of Chlor-Alkali Manufacture: All Chlor Alkali Plant in India produce hydrogen as by byproducts of chemical processes, such as those at Jaishree Chemicals in Ganjam, Odisha.

The storage and transportation of hydrogen require specialized systems, including compressed gas in underground caverns, cryo-compressed tanks, and liquefied hydrogen storage. Transport options include pipelines, tube trailers, liquefied hydrogen trucks, and blending hydrogen with compressed natural gas (CNG).

**Hydrogen Fuel Cells: A Revolutionary Energy Solution**

Fuel cells, particularly Proton Exchange Membrane (PEM) fuel cells, are emerging as one of the most promising applications of hydrogen. These electrochemical devices convert chemical energy into electricity, with water and heat as byproducts.: During March 2025, hydrogen fuel cell vehicle are just been launched by Tata Motor and Indian Oil. The primary advantages of hydrogen fuel cells include:

- Zero vehicle emissions
- High fuel efficiency
- Quick refueling time (5 minutes)
- Eco-friendly production potential

- Compatibility with existing gasoline infrastructure

Despite these advantages, challenges remain, particularly in terms of safety due to hydrogen's flammability and the relatively nascent state of hydrogen fuel cell vehicles.

**Global Hydrogen Program Initiatives**

Hydrogen is gaining global attention, with countries around the world embarking on ambitious programs to scale up hydrogen production and utilization. Some key developments include:

1. European Union: The EU's Hydrogen Strategy for Climate-Neutral Europe aims to generate 2250 Terawatt Hours (TWh) of hydrogen energy by 2050, with a focus on decarbonizing transport, industry, and heating. This will significantly reduce CO2 emissions and meet the EU's energy needs.
2. Netherlands: The Netherlands is building a green hydrogen facility capable of producing 800,000 TPA by 2040, using offshore wind power.
3. Australia: Australia is focusing on its abundant renewable energy resources to produce green hydrogen, with projects such as the Hydrogen Park at Gladstone.
4. China: China is investing heavily in solar and wind-powered hydrogen production, with large electrolyser plants to support its growing demand for green hydrogen.
5. South Korea: South Korea is positioning hydrogen as a key fuel for the transport sector, including trucks, trains, and airplanes.

**Hydrogen Initiatives in India**

India is also making strides in the hydrogen space. The country is participating in the global "Mission Innovation" initiative, which aims to accelerate clean energy innovation. The Indian government has initiated the "Hydrogen Valley Platform," a collaborative effort to integrate hydrogen applications into a national ecosystem. The platform will focus on four key areas:

1. Hydrogen production
2. Hydrogen sharing
3. Hydrogen utilization
4. Addressing cross-cutting issues

**Way Forward: Building a Hydrogen Economy**

To transition toward a hydrogen-based economy, the following actions are essential:

- Support R&D: Investment in research and development of hydrogen production, storage, and transportation technologies is crucial.
- Develop a Roadmap: A clear strategy for scaling up hydrogen use across sectors must be developed, addressing the socio-economic barriers to adoption.
- Promote International Collaboration: Partnerships between governments, industries, and academia are key to accelerating the hydrogen revolution.
- Policy Support: Governments should introduce policies and incentives to promote hydrogen production, use, and infrastructure development.

The hydrogen economy holds immense promise as a sustainable solution to the world's energy challenges. While the upfront costs are high, the long-term benefits—including a reduction in greenhouse gas emissions, energy security, and a cleaner planet—make hydrogen a critical tool in the transition to a sustainable energy future.

**Conclusion**

Hydrogen's role in addressing global energy and climate challenges is becoming increasingly important. With ongoing research, technological advancements, and strategic investments, hydrogen can become a cornerstone of the world's energy landscape. The collective global effort to promote hydrogen production, storage, and utilization is essential for mitigating the impacts of climate change and building a sustainable, decarbonized future.

# Energising the Future :

## How the Low-Carbon Transition will boost economic growth and transform the workforce

- Rajib Roy and Gora Chakraborty

Rajib Roy, a seasoned oil and energy professional with over 13 years of experience, holds undergraduate and postgraduate degrees in Chemical Engineering from Jadavpur University, Kolkata. He specializes in conceptual engineering for oil and gas processing, enhanced oil recovery, well completion design, and formation damage remediation. His expertise extends to mature field development, well integrity optimization, and energy efficiency. Additionally, he is a WellSharp IADC Well Control Trainer and has experience in procurement and SAP operations.

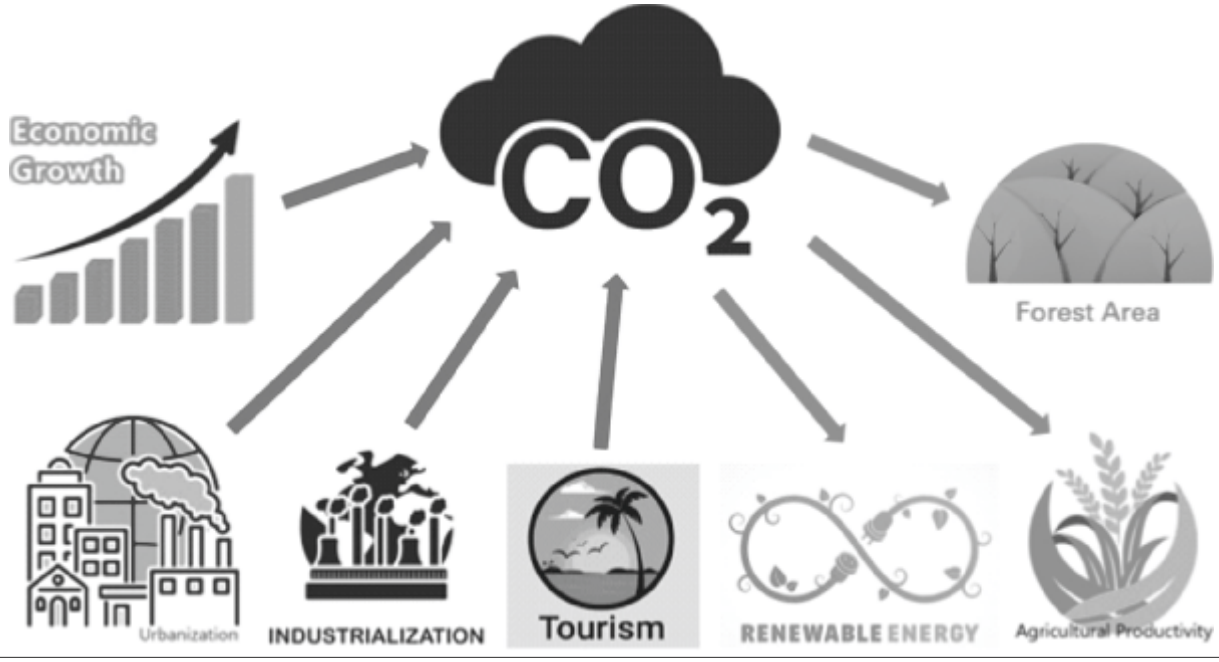
Currently pursuing a PhD in Chemical Engineering at IIT Delhi under Prof. K. K. Pant, Rajib focuses on hydrogen energy and carbon-free fuel production. A thought leader in energy transition, he has delivered guest talks on hydrogen's role in the future energy mix. Passionate about sustainability, he aims to drive a decarbonized economy through innovations like in-situ aquathermolysis for low-carbon fuel production and seeks collaborations in hydrogen and sustainable energy solutions.

**Abstract**

This paper provides a comprehensive analysis of the multifaceted interplay between energy, economy, and employment in India while critically assessing the evolution of the country's labour market. Drawing on a case study of West Bengal's recent energy expansion, an intensive review of Ajit Kumar Ghose's Employment in India, and insights from Leggewie and Messner's "The low-carbon transformation—A social science perspective" (2012), the paper synthesises policy frameworks, industry impacts, global comparative experiences, and macroeconomic trends. Data, tables, figures, and empirical evidence from sources such as "The Indian Economy – A Review, Jan 2024" are used to illustrate how strategic energy investments and targeted labour reforms—combined with a consciously steered low-carbon transformation—can drive sustainable and inclusive growth in India.

**Introduction :**

The dynamic interconnection between energy, economy, and employment is central to a nation's progress. Reliable energy fuels industrial activity, drives economic growth, and underpins a broad array of employment opportunities. The transition



toward sustainable and resilient energy systems is paramount in today's rapidly evolving global landscape. Regions that implement innovative policies and invest strategically in energy infrastructure are poised to secure a competitive edge.

A compelling example of such forward-thinking is the West Bengal government's recent decision to allocate land for ONGC's new oil and gas production facilities. This transformative initiative is designed to enhance energy security, attract industrial investments, generate diverse job opportunities, and strengthen fiscal health. In parallel, understanding the evolving employment landscape is crucial; Ajit Kumar Ghose's Employment in India provides a critical primer on the structure and challenges of the Indian labour market.

Moreover, the urgency of climate change has led to increased focus on transitioning to a low-carbon economy. Leggewie and Messner's "The low - carbon transformation—A social science perspective" (2012) argues that achieving global climate compatibility requires a comprehensive socio-technical, economic, and cultural transformation steered by political will and innovative policies. This paper integrates these themes to present a holistic view of India's developmental trajectory, addressing traditional energy and employment dynamics and the emerging imperatives of low-carbon transformation.

## 2. The Intersection of Energy, Economy, and Employment in India

### 2.1 Energy as a Catalyst for Economic Growth

Energy is the critical input for economic development, playing a multifaceted role:

Enabling Industrial Production: Reliable energy supplies are essential for industries ranging from steel and cement manufacturing to advanced IT infrastructure.

Boosting Agricultural Productivity: Energy powers mechanisation, irrigation, and food processing, increasing crop yields.

Expanding the Services Sector: Key services such as transportation, healthcare, banking, and telecommunications depend on consistent energy access.

Empirical evidence from the International Energy Agency (IEA, 2023) indicates that a 1% increase in energy consumption in developing economies can lead to an approximate 0.8% rise in GDP.

### 2.2 Employment Creation Driven by Energy

The energy sector contributes to job creation in the following ways :

Investments in renewable energy and efforts to reskill the workforce are essential as the economy shifts from fossil fuels to cleaner energy sources.

| Employment Category | Illustrative Examples |
|---|---|
| Direct Employment | Jobs in energy production, exploration, refining, engineering, and grid management. |
| Indirect Employment | Roles in equipment manufacturing, logistics, and supply chain operations. |
| Induced Employment | Increased incomes fuel retail, real estate, education, and services opportunities. |

## 3. West Bengal's Energy Expansion: A Case Study in Economic Transformation

### 3.1 Overview of the ONGC Initiative

The West Bengal government's decision to allocate land for ONGC's oil and gas production marks a strategic milestone with several anticipated benefits:

- Enhanced Energy Security: Strengthening local energy infrastructure reduces dependency on imported fuels and stabilises prices.
- Industrial Attraction: A stable energy base draws investments from petrochemicals, steel, and manufacturing sectors.
- Job Creation: The initiative is expected to generate a broad range of employment opportunities, from direct energy operations to ancillary support services.
- Fiscal Enhancement: Increased industrial activity will likely boost state revenues through higher taxes, royalties, and licensing fees.

### 3.2 Policy Environment Supporting the Initiative

Supportive policy measures reinforce the initiative:

| Policy | Relevance |
|---|---|
| India's Hydrocarbon Vision 2030 | Promotes domestic exploration and production to reduce import dependency. |
| Atmanirbhar Bharat (Self-Reliant India) | Focuses on strengthening local energy infrastructure and achieving self-reliance. |
| National Hydrogen Mission | It lays the groundwork for integrating green hydrogen into the energy mix. |
| West Bengal Industrial Policy 2022 | Provides incentives and regulatory support for energy and infrastructure investments. |

These policies collectively aim to reduce fossil fuel imports by 50% by 2035, reinforcing long-term economic resilience.

## 4. Energy and Economic Growth: An Integrated Perspective

### 4.1 Role of Energy in Driving Economic Performance

Energy is foundational to economic stability and growth:

- Industrial Input : Increased energy consumption is linked with higher industrial output and GDP (Stern, 2011).
- Economic Stabilization : Reliable energy reduces dependency on volatile imported fuels, curbing inflation and mitigating economic fluctuations (World Bank, 2023).
- Facilitating Renewable Adoption : Investments in renewable energy support environmental sustainability and long-term economic resilience (IEA, 2023).

### 4.2 Impact of Energy Prices on the Economy

| Energy Source | Economic Impact | Price Volatility |
|---|---|---|
| Oil & Gas | Drives inflation and influences transport costs | High |
| Coal | Supports heavy industries; declining relevance | Medium |
| Solar & Wind | Promotes affordability and job creation | Low |
| Hydrogen | An emerging sector with potential economic disruptions | Medium-High |

A strategic shift toward renewables promotes energy independence and creates a diversified, sustainable industrial base.

## 5. Energy and Employment: Transitioning to a Green Economy

### 5.1 Traditional vs. Renewable Energy Employment

The employment landscape in the energy sector is evolving, as evidenced by the following data:

Expansion of Green Jobs: Renewable sectors like solar, wind, and hydrogen are rapidly expanding.

Robust retraining programs are needed for workers transitioning from fossil fuels to renewable energy. Innovations such as AI-driven smart grids are redefining workforce requirements.

### 5.2 Strategies for Workforce Reskilling and a Just Transition

| Sector | Current Employment Share (2023) | Projected Employment Share (2030) |
|---|---|---|
| Fossil Fuels | 65% | 30% |
| Renewable Energy | 35% | 70% |

*(Source: IRENA, 2023)*

A successful transition necessitates:

**Training Programs:** Extensive investments in skill development to prepare workers for emerging technologies.

**Inclusivity:** Promoting greater participation of women and marginalised communities in STEM fields.

**Adapting to Automation:** Emphasizing high-tech skill development and continuous learning as automation increases.

## 6. Critical Review of Employment in India by Ajit Kumar Ghose

Ajit Kumar Ghose's Employment in India offers a comprehensive primer on the evolution of India's labour market since Independence.

6.1 Structure and Key Themes

Conceptual Framework: The book introduces key concepts such as the distinction between modern and traditional sectors, wage versus self-employment, and formal versus informal labour.

Empirical Analysis: Ghose examines employment trends from 1950 to 2016 using data from the NSSO, Labour Bureau, Directorate General of Employment and Training, and Census.

Phases of Employment Trends: The analysis identifies distinct phases in India's labour market evolution:

| Phase | Period | Key Observations |
|---|---|---|
| Phase 1 | 1955 – 1978 | The dominance of traditional sectors results in limited formal employment. |
| Phase 2 | 1978 – 2000 | Gradual increase in wage employment; early structural transformation. |
| Phase 3 | 2000 – 2012 | Intensification of service-led growth; underdevelopment of manufacturing. |
| Phase 4 | 2012 – 2016 | Further, there is a rise in wage employment and a decline in self-employment. |

Table: Phases of Employment Trends in India (1955–2016)
Service-led Growth and Gender Dimensions: The book highlights the paradox that low-skilled employment and female participation remain critical challenges despite robust economic growth driven by the service sector.

Policy Roadmap: Ghose suggests a need for a strategic focus on generating approximately 12.5 million jobs per annum, particularly in low-skilled sectors, to achieve structural transformation.

### 6.2 Critical Evaluation

Strengths: The book's rigorous empirical analysis and clear explanation of complex employment concepts make it a valuable resource for researchers and students.

Limitations: While data-rich, detailed statistical analyses may be challenging for non-specialists, explanatory boxes help clarify key terms and concepts.

## 7. The Low-Carbon Transformation: A Social Science Perspective

Leggewie and Messner's article, "The low-carbon transformation—A social science perspective" (2012), offers a framework for understanding the profound changes needed to transition from a fossil-fuel–based economy to a low-carbon, resource-efficient system.

### 7.1 Theoretical Frameworks and Historical Context

Historical Parallels: The authors compare the current transformation to the Neolithic and Industrial Revolutions, emphasising that, unlike these unplanned transitions, the low-carbon shift must be consciously engineered.

Long-Wave and Evolutionary Theories: Fundamental innovations occur in cycles (every 40–60 years); however, the urgency of climate change requires accelerating these cycles.

Co-Evolution and Multi-Level Dynamics: Societal subsystems (economic, technological, cultural, ecological) co-evolve. Tipping points—such as cost parity between fossil fuels and renewables—can trigger rapid shifts to low-carbon development.

### 7.2 Social and Policy Implications

Changing Narratives: A critical element is the development of new narratives that move away from endless fossil-fuel growth to models emphasising sustainability, equity, and resource efficiency.

Labour and Social Justice: A just transition must include robust retraining programs, social safety nets, and public or cooperative ownership of energy assets to ensure that vulnerable workers are not left behind.

Global Cooperation: Achieving a low-carbon future requires unprecedented international cooperation and a redefinition of global social contracts.

### 7.3 Dynamics of Transformation

Multi-Level Processes: Transformation occurs through interactions between the established high-carbon regime, emerging change agents, and evolving policy frameworks.

Tipping Points and Co-Evolution: As illustrated by the Transformation Trajectory S-curve (Figure 1 in the original article), rapid transformation becomes likely once renewable energy sources reach cost parity with fossil fuels.

## 8. Integrating Low-Carbon Transformation with India's Development Agenda

### 8.1 Challenges and Opportunities

India faces a dual challenge: decarbonising its economy and ensuring inclusive growth. Key issues include:

Technological and Policy Barriers: Accelerating low-carbon innovation while overcoming entrenched interests.

Labour Market Implications: Ensuring the transition creates new job opportunities and provides robust support for displaced workers.

Global Competitiveness: Aligning India's energy strategy with international sustainability goals while maintaining economic growth.

### 8.2 Strategic Recommendations

Policymakers should consider:

Enhancing Energy Security: Diversify energy sources and invest in decentralised grids.

Promoting a Just Transition: Implement large-scale reskilling programs and ensure public ownership of critical energy assets.

Fostering Innovation: Support research and development in renewable energy technologies and low-carbon solutions.

Strengthening International Cooperation: Engage in global coalitions to share best practices and coordinate low-carbon strategies.

## 9. Conclusion

The review of Leggewie and Messner's "The low-carbon transformation—A social science perspective" highlights that achieving a sustainable, low-carbon future is not simply a technological challenge but a comprehensive socio-economic

transformation. When integrated with insights from West Bengal's energy expansion and Ajit Kumar Ghose's analysis of India's labour market, it becomes evident that India stands at a crossroads. Strategic energy investments, targeted labour reforms, and progressive policy frameworks can drive sustainable and inclusive growth.

This extensive review underscores that for India to navigate the complex transition to a low-carbon future, it must adopt a holistic approach that harmonises energy security, economic development, and social equity through employment, paving the way for a resilient and prosperous future.

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# The Missing Fourth Dimension : The "Environment" in the Discourse on Economics, Energy, and Employment

- Meghdut Manna

**An alumnus of Jadavpur University, Meghdut Manna graduated with a B.Tech in Instrumentation and Electronics Engineering in 1998. A dedicated member of the Mumbai Alumni Chapter, he has played a pivotal role in its growth and success, contributing actively to its initiatives and engagements.**

**Time as the Fourth Dimension: Environment as the Temporal Fabric of Human Civilization**

For over two millennia, human understanding of space was confined to the rigid framework of three-dimensional Euclidean geometry. However, this perception was profoundly altered by Albert Einstein and his professor Hermann Minkowski, who introduced the concept of space-time—an inseparable continuum where 'time' emerged as the fourth dimension.

Yet, unlike spatial dimensions, humans cannot directly perceive time. We are prisoners of the present, incapable of reliving the past or fully envisioning the future. Despite this limitation, time is the fundamental governing principle of the universe, dictating the unidirectional flow of events under the inexorable laws of physics and entropy.

Similarly, in discussions surrounding economics, energy, and employment, the environment functions as the temporal dimension—an intrinsic yet often disregarded factor that can never be separated from human progress. And just like time, environmental destruction is unidirectional and irreversible. As Francis Bacon once suggested, humans have transformed the world for their own benefit, but in doing so, they have subjected nature to relentless extraction and torment in their pursuit of its secrets.

**The Geological Timeline: A Blink in Earth's History, Yet a Catastrophe in the Making**

Astrophysicist Nigel Calder once envisioned Earth as a 46-year-old woman, compressing its 4.6 billion-year history into a comprehensible scale. On this timeline, Homo sapiens arrived merely four hours ago, recorded human history began fifteen minutes ago, and the Industrial Revolution—which fundamentally altered the planet—occurred in the final sixty seconds before midnight.

Despite this fleeting presence, humanity has already pushed Earth toward an existential crisis. As historian Dipesh Chakrabarty argues, the problem we face is not merely an environmental crisis but a planetary-scale disruption. The once-resilient face of Gaia, as poetically articulated by James Lovelock, is vanishing before our eyes.

**Tagore: A Prophet of Environmental Consciousness**

Rabindranath Tagore was remarkably ahead of his time in understanding and expressing the dangers of environmental destruction, even more so than today. His vision challenged the Cartesian and Baconian ideals of civilization, which championed human dominion over nature. Long before the concept of "sustainable development" gained global recognition—popularized by Gro Harlem Brundtland in the 1987 Brundtland Report—Tagore had already woven its essence into his literary and philosophical works. His masterpieces, such as *Muktadhara* and *Rakta Karabi*, stand as profound critiques of unchecked industrialization and its impact on society and nature.

While climate activism has become widespread today—often diluted by performative over-activism—Tagore was a true pioneer of eco-literacy. Decades before contemporary movements like "Save Soil", he delivered a groundbreaking lecture titled "The Robbery of the Soil" on July 28, 1922, at Calcutta

University, under the Visva-Bharati Samiti. His speech was deeply rooted in the civilizational crisis that we face today—an accelerating imbalance between urban and rural life, driven by the relentless greed of a privileged few.

Warning against the intoxicating illusion of progress, he observed:

*"In such a society, people become intoxicated by the constant stimulation of what they are told is progress... This passion of greed that rages in the heart of our present civilization, like a volcanic flame of fire, is constantly struggling to erupt in individual bloatedness."*

Lamenting the loss of harmony between nature and human existence, Tagore longed for the world he once knew, exclaiming:

*"Give me back my known forest and take back this urban civilization!"*

His words resonate today, serving as a poignant reminder that true progress cannot come at the cost of nature's annihilation.

**The False Wisdom of Human Invincibility**

For centuries, humanity clung to the belief that Earth's natural processes were immutable, too vast to be altered by human activity. This illusion shattered as our large, intelligent brains devised ways to burn fossil fuels, industrialize landscapes, and exploit ecosystems at an unprecedented scale.

We have terraformed the planet, creating an "Anthroposphere" or "Technosphere," fundamentally altering the chemistry of the Geosphere and Biosphere—changes that, under natural geological processes, would have taken millions of years. Some scientists argue that we have already exited the Holocene epoch and entered a new age: the Anthropocene.

But is this truly the Anthropocene, the age of "humans"? Or is it more accurately the Capitalocene, driven by the unquenchable thirst of capitalism? As Amitav Ghosh compellingly argues in *The Nutmeg's Curse*, colonial powers—from the Dutch East India Company to the British Empire—not only subjugated peoples but systematically exploited and destroyed ecosystems across the globe.

**From Homo Sapiens to Homo Industrial**

For 99% of our existence, humans lived as hunter-gatherers, deeply embedded in natural ecosystems. But today, we are more accurately Homo Industrial, creating artificial empires by extracting, exploiting, and engineering nature.

The Fourth Industrial Revolution, driven by Artificial Intelligence (AI), is poised to reshape—or destabilize—human civilization even further. While collective intelligence has enabled us to achieve technological marvels—from space exploration to genetic engineering—it has also irreversibly transformed the planet's ecological balance.

**The Great Acceleration: A Century of Unprecedented Change**

Although human impact on climate began with agriculture 10,000 years ago, the real acceleration occurred in 1950. In a mere seven decades, we have achieved staggering advancements—petrochemicals, genetic technologies, nuclear energy, space travel, and AI—but at what cost?

Our quest to understand the infinitely vast (the universe) and the infinitely small (quantum particles) has expanded exponentially. But in our obsession with progress, we may have created a Frankenstein's monster—an industrial engine whose growth is fundamentally unsustainable.

**Fossil Fuels: The Carbonivorous Dilemma**

Despite acknowledging the climate catastrophe, humanity remains addicted to fossil fuels. Jules Verne, in *The Purchase of the North Pole*, prophetically called humans " Carbonivorous" animals.

Every aspect of modern life—electricity, transportation, medicine, infrastructure, consumer goods—is powered by fossil fuels. Even "green technologies" like solar panels, wind turbines, and electric vehicles rely on the mining of rare-earth metals, an industry itself heavily dependent on fossil energy.

This presents an inescapable Trolley Problem:

- If we continue burning fossil fuels, we accelerate climate collapse.
- If we stop suddenly, civilization crumbles.

How do we reconcile survival with sustainability?

**Energy: The Universal Currency of Civilization**

Physicist Vaclav Smil describes energy as the true universal currency—the fundamental force behind every economic, technological, and biological process.

As Robert Ayres put it,

*"The economy is essentially a system for extracting, processing, and transforming energy into products and services."*

Yet, for all our technological prowess, humans cannot generate a single joule of energy themselves. Every energy source—solar, fossil, nuclear, wind, biomass—is merely borrowed from nature. And in this borrowing, we have radically altered the environment.

**Exponential Growth: The Greenhouse Effect in Action**

The numbers tell a stark story:

- In 1950, the global population was 2.5 billion. Today, it is 8.2 billion.
- Since 1950, humanity has consumed 24 zettajoules (ZJ) of energy—almost double the total energy used in the entire 11,500-year Holocene period.
- Atmospheric $CO_2$ levels have soared from 280 ppm to 420 ppm, fueling climate instability.

This exponential expansion is unsustainable—a Malthusian nightmare unfolding in real-time.

**The Illusion of Climate Promises: Greenwashing & Stagnation**

From the 1992 Rio Summit to COP29, we have seen countless pledges to combat climate change. Yet, these promises remain largely performative—mere greenwashing while nations continue to prioritize economic expansion over planetary survival.

Even as renewables like hydrogen and wind are touted as solutions, global energy systems remain overwhelmingly dependent on fossil fuels, with little political will to curb consumption.

**Doomsday Clock or Hope?**

I began this article by presenting Time as a metaphor for the fourth dimension, drawing a parallel between its irreversibility and the environmental crisis we face today. In 1947, J. Robert Oppenheimer introduced the Doomsday Clock, a symbolic representation of humanity's proximity to a self-inflicted global catastrophe. While not a literal prediction, it serves as a chilling metaphor for an impending apocalypse—one that climate change could bring to reality.

Unchecked economic expansion, rampant population growth, and the illusion of infinite progress have pushed our planet to the brink. If we fail to curb greenhouse gas emissions and reverse our destructive trajectory, there may come a time when no one is left to remember us—no future civilization to unearth our fossils and decipher our downfall.

If humanity refuses to recognize the environment as the missing fourth dimension essential for our survival, the Apocalypse is not a distant threat—it is imminent.

As Sukanta Bhattacharya wrote: *"I will make this world habitable for this child; this is my firm pledge to the newborn."*

Can we fulfil that promise?

✦✦✦

## Interesting facts about the Indian economy:

**Here are some interesting facts about the Indian economy:**

**1. Fastest-Growing Major Economy**

India is projected to be the fastest-growing major economy in the world, with a GDP growth rate of around 6-7% annually.

**2. 5th Largest Economy (Soon to be 3rd)**

India overtook the UK in 2022 to become the 5th largest economy in the world. It is expected to surpass Japan and Germany by 2027, making it the 3rd largest economy.

**3. Largest Population & Workforce**

With 1.4 billion+ people, India has the world's largest population and a workforce of over 600 million people, contributing to its economic dynamism.

**4. IT & Software Powerhouse**

India is the world's largest outsourcing hub for IT services, contributing 8% of GDP. It is home to major global tech hubs like Bangalore, Hyderabad, and Pune.

**5. Digital Payments Leader**

India leads the world in digital transactions, with UPI (Unified Payments Interface) processing over 100 billion transactions annually, surpassing the US and China.

**6. Stock Market Boom**

The Indian stock market (BSE & NSE) is among the top 5 largest globally, with India's market capitalization surpassing $4 trillion in 2024.

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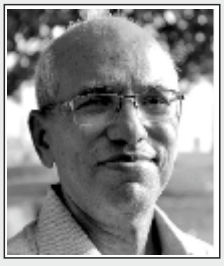
# Indian Nuclear Submarine Program

- Gora Chakraborty



Gora Chakraborty graduated in Electrical Engineering from Jadavpur University in 1967 and earned an MTech in Power System Engineering from IIT Kharagpur in 1975. He joined BARC Trombay in 1967 and retired in 2006. Initially, he worked on the design and development of a nuclear submarine with the Indian Navy. In 1978, he shifted to Nuclear Power Plants and became an expert in their safety and development. He developed computer codes for safety analysis of Indian Nuclear Power plants and worked extensively with the Nuclear Power Corporation of India Ltd. on design modifications of Indian Pressurized Heavy Water Reactors (PHWRs). He also worked with the Atomic Energy Regulatory Board for the licensing of Indian Nuclear Power plants.

After retiring from BARC, he worked as a full-time consultant with Tata Consulting Engineers Ltd. and as a visiting professor at Delhi University and Petroleum Science & Energy University in Dehradun. Currently, he writes in Bengali and contributes to magazines on scientific and social matters. He has received several awards, including the INS Science Communication Award 2005 from the then PM of India Dr. Manmohan Singh; the Meghnad Saha Award 2005 from the Department of Science and Technology for writing a book in Hindi on Indian Nuclear Power Plants; the Surendra Nath Smriti award from Nikhil Bharat Banga Sahitya Sammelan, Delhi in 2006 for science writing in Bengali; and the Kedarnath Bandyopadhyay Smriti Award for his contribution to Bengali Literature in 2012.

This paper is on such a subject where man and money are not a criterion, but it's the need of the hour for the defence of the country. Again, I shall not cite any reference literature, as it's a defence matter of the country; as such, it's a secret. However, all the pictures and information in general are available on the open internet and print media.

First, I will deal with the technology, and then I shall go with the needs and benefits of the country. In 1967, the DAE (Directorate of Atomic Energy) was approached by the Indian Navy to build and fabricate a nuclear submarine. A small group was formed, and the Indian Navy deputed a few senior engineers in our section to work on this project. I was lucky to be associated with this group. In 1971, during the Bangladesh war, when the US Navy's Seventh Fleet, which was fully powered by nuclear energy, started approaching Chittagong, the Pakistani Army surrendered. The need for a nuclear submarine intensified.

I was deputed to IIT Kharagpur for two years with a small assignment in 1973. When I was in Kharagpur, India detonated an underground nuclear bomb at Pokhran in Rajasthan in 1974. After I returned to BARC in 1975, I found the submarine group had gone on the back foot, and it became important to finish the construction of the RAPP-II NPS (Nuclear Power Station). I left the submarine group and started working on Nuclear Power Stations.

In 1981, Rajasthan II became critical, and in 1982, it started commercial operation. Gradually, India became self-sufficient in nuclear technology. India detonated five more underground nuclear bombs of different kinds in 1998 and unilaterally declared that India would not explode any more nuclear bombs. Though India did not sign the NPT (Non-Proliferation Treaty), the USA came forward and signed the “121st Nuclear Treaty” for cooperation in nuclear civil power generation.

The nuclear submarine group, which was working inside BARC, meanwhile shifted to Kalpakkam, Chennai, and made the land-based

submarine reactor, which started working during the mid-nineties of the last century. After this, the joint project of DAE and the Indian Navy, with the experience gathered in this land-based reactor, produced the first Indian nuclear submarine INS Arihant, which started its sea operation in 2013. After extensive sea trials for five years, it joined the Indian Navy's fleet in 2018.

Here's a quick explanation of how nuclear submarines work. In the picture below (Fig. 1), the Indian submarine INS Arihant can be seen on the surface of the Bay of Bengal's seawater. This picture was on the internet in 2018 when it was finally handed over to the Indian Navy.

Fig-1: The INS Arihant floating on sea surface

In the next picture (Fig. 2), we see the arrangement of the nuclear power reactor, which supplies high-pressure steam to the turbine shaft and drives it. The reader is requested to follow the figures while reading for clarity. The turbine shaft is connected directly to the submarine propulsion system. On the main propulsion shaft, an Electric propulsion motor is also connected for emergency propulsion purposes. A fraction of the main steam coming out of the steam generator is fed into a turbine generator system for generating the submarine's electricity needs. The turbine-generator system is also connected to an electrical bus system, which connects to a robust storage battery. In the event of a turbine-generator failure, this battery will supply electricity. The storage battery also supplies electricity in case of main turbine failure, generating the propulsion torque needed for the submarine to enter safe mode. Nuclear fission generates heat in the nuclear fuel. This heat is removed by coolant water. The heated coolant enters the steam generator, where it exchanges heat with secondary coolant water to generate steam. The primary coolant, after cooling, flows back into the reactor core to extract heat from the fuel. The whole process system can be followed in Fig. 2 and operates in a closed loop.

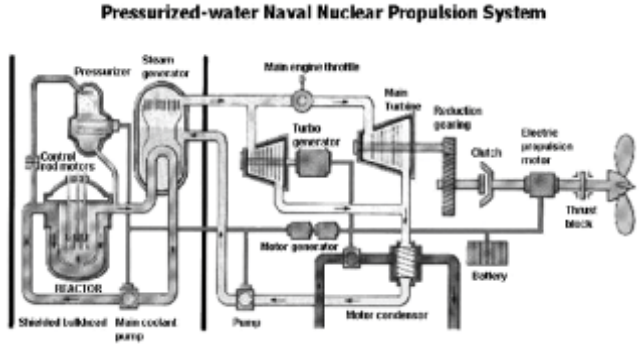



**Fig:2 Nuclear propulsion system**

The fuel used in the reactor core is in the form of highly enriched uranium oxide rods cladded inside a special metallic alloy tube. A reactor's fuel loaded inside the reactor will generate energy for its lifetime. If the need comes for changing the fuel because of its failure, the submarine will have to be taken to a special jetty. On this jetty, the hull will be perforated in a designated area, and then, with utmost safety, the top of the reactor vessel will be unscrewed and opened. The old, irradiated fuel assembly will be removed and sent for reprocessing in shielded containment. Fresh fuel will be loaded through the hull hole in the reactor core. Gradually, all the piping connections will be made, and the hull hole will be welded back. This refuelling may take a year or more. Now a days fuel is designed to last for seventy years. So, the problem of refuelling during a nuclear submarine's lifetime is almost absent.

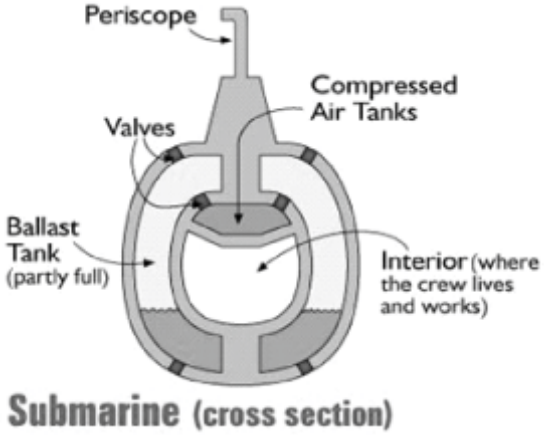



Fig 3: Cross-section of the hull

The hull of a submarine is a double-walled vessel, as shown in the cross-section in Fig 3. The space between the two walls is void and is called a 'ballast tank'. There is a compressed air tank which is connected to the ballast tank with the help of two valves. Normally, these two valves are kept closed. There are four valves connected to the outer wall, which are kept closed under normal conditions.

When the submarine wants to go deep in the water, the two valves of the compressed air tank will be kept closed and all the four valves in the outer wall of the ballast tank will be kept open. Under this condition, seawater will enter the ballast tank. The upper two valves will vent the air of the ballast tank, which will be filled with seawater. The vessel's weight will increase, and the submarine will start going below water. When the vessel achieves the desired water depth, all the valves will be gradually closed. After this, with the propeller the submarine will start its motion in the desired direction. When the submarine wants to come to the surface, the two lower valves of the ballast tank will be opened. Then, the two lower valves of the compressed air tank will be opened. The high-pressure air will enter the ballast tank and will start discharging the water inside the ballast tank to the sea through the two lower valves of the ballast tank. The vessel will become lighter and come to the surface of seawater.

After it surfaces, all the valves in the compressed air tank and the ballast tank will be closed. All surface vessels and land surface vehicles can move only in the right and left forward and backward motions. But the submarine has to move in all six directions like an aircraft. This is done with movable fins at the tail end of the submarine body. Another problem of the submarine is rolling and pitching. Rolling is mostly prevented by design, shifting the centre of gravity at the bottom of the vessel, just like the surface vessels. The propeller and the movable fin flaps control the pitching and direction of the vessel.

The hull of a nuclear submarine is made from a very special steel alloy which does not react chemically with the seawater at all. As a result, the hull need not be changed for the whole life of the submarine. If the hull becomes transparent like glass, then how it will look is shown in Fig 4. On the front side of the submarine is a sonar, which helps to see the presence of enemy targets and helps the submarine to go forward. To help with this the back side is also fitted with a sonar. On the front side, there is a hump on the submarine body where a periscope and other communication instruments are fitted and kept. Just below the hump is kept the war-fare inventory, submarine control room and the weapons. As you can see in the figure, just after that, on the back side are kept the ballistic missiles, which can carry any type of bomb, including nuclear. The missiles are capable of firing from under the sea water. After the missile room, first is the reactor room and then the

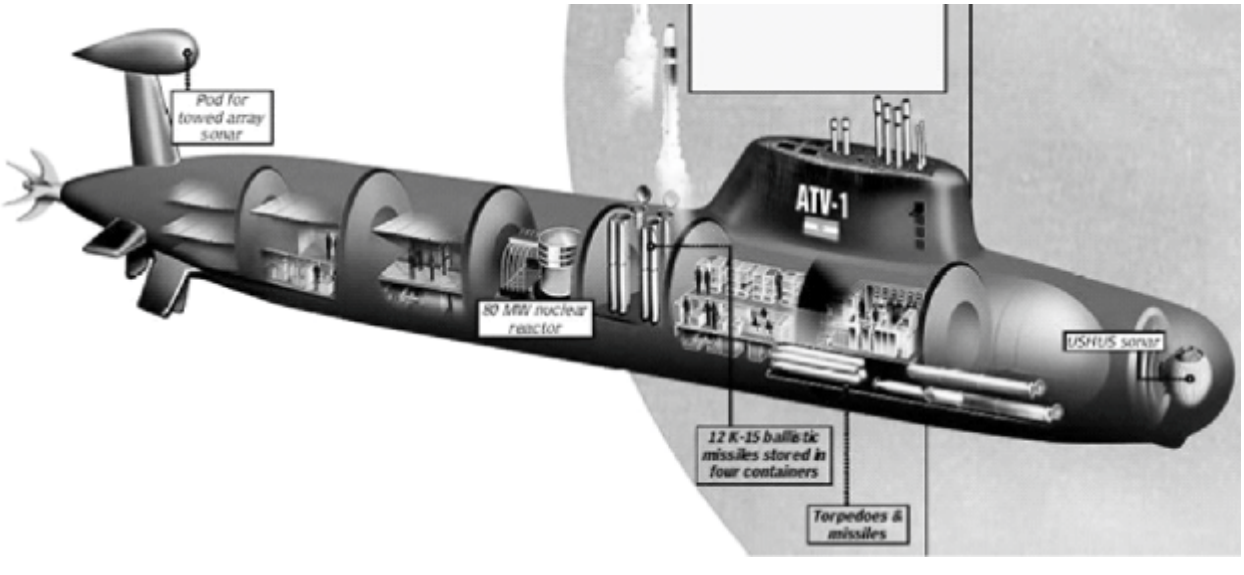



Fig 4: Inside layout of a nuclear submarine

instrument maintenance room. After that, the submarine workers' dining room, recreation room and, at the end, the restroom.

Let us now discuss the intricacies and advantages of a nuclear submarine. In a submarine, the workers and operators must work in a closed atmosphere, and they must breathe oxygen. In the case of diesel or battery-operated submarines, the vessels have to surface at least once a day to purge out the already oxygen-depleted inside air and take fresh air inside from the atmosphere. Fresh air is also needed for the diesel engine for combustion of the oil to generate the propulsion power. If it's battery-driven, then after surfacing, with the help of a diesel generator set, the depleted batteries will be recharged. Because of these difficulties, the operating range of the diesel or battery-driven submarines is limited to 40 to 80 miles from the main Cruze surface vessel or from the war port. These problems are absent in a nuclear submarine. Because it does not need to surface at all for a prolonged period. Energy is available inside in the form of electricity to use for any work and steam-turbine shaft for propulsion of the submarine.

Let us see the list which are prepared inside the vessel to meet the daily needs.

1) Seawater can be desalinated to produce both potable water for human needs as well as demineralized water for the machine's needs, particularly for the turbine.
2) Oxygen can be prepared by electrolysis of seawater, and unwanted hydrogen can be released into the ocean water, just like the dumping of human and biological wastes into the ocean.
3) The carbon dioxide level inside the submarine chamber will go up due to human breathing. The $CO_2$ can be absorbed in water inside a percolator and discharged in ocean water from time to time. Methane and other biological gaseous materials will be removed continuously through an air purifier and


Fig 5: US nuclear aircraft carrier in a US Naval fleet

purged into the ocean water.

4) Solid and liquid biological wastes will also be purged out of the vessel from time to time to maintain decent atmospheric conditions for the crewmembers.

5) Cooking also is easier by use of all electrical gazettes. The only problem is the storage of grains, spices and vegetables. Vegetables cannot be stored for a prolonged period in the freezers as the vitamin content in them gets depleted. The vitamin is important for human consumption for the good health of the nervous and body system. Of course, vitamin supplements will serve the purpose. But proper dose and absorption capability of individuals varies from person to person. Overdose also creates problems.

   Hence, it is found that the limitation of how much time a nuclear submarine can remain under seawater is the fresh vegetable stock that can be kept in the storage system. It has been found that a maximum of six months is all right for the healthy operation of its Crue-members.

6) The speed of diesel-driven and battery-driven submarines is limited to 30 to 60 nautical miles per hour underwater. But a nuclear submarine can achieve a speed of 60 to 100 nautical miles per hour or higher comfortably.

7) The nuclear power reactor of the normal submarines is around 85 MW (thermal). But for special purposes, the thermal rating may go as high as 95MW.

The statistics of the defence department are a secret matter of a country. The author has tried his level best to collect some defence data of important countries. From the internet, some data and photographs which had been gathered are being reproduced so that the readers can have some idea of where we stand. In 1997, the US and Russia signed a “Nuclear Disarmament Treaty” to end the Cold War that prevailed at that time in the world. After the Treaty, the nuclear vessels of the different countries became as below. Nuclear Submarine: US (100), Russia (100), Britain (20), France (20), China (6). Besides this, the US has 5 nuclear aircraft carriers, and Russia has 10 nuclear cruisers and 5 nuclear icebreakers. As of now, China might have added a good number of nuclear submarines. As of now, India has 2 nuclear submarines. Another nuclear submarine will join the Indian Navy at any time this year, 2025. India, at present, has decided to have an inventory of 6 nuclear Submarines in their Naval fleet.

Its an important decision by India that India will never use a nuclear bomb to destroy human civilization. Still, it detonated under-ground peaceful nuclear bombs one in 1974 and five in 1998. After this India unilaterally declared a moratorium on nuclear Bomb. India claimed that it had experimented successfully on all types of nuclear bombs and needed no more explosions of nuclear bombs. India said that the nuclear bomb project was only for the deterrent program of the country, but not for any war purposes. India has taken a vow that it will never be the first country to detonate a nuclear bomb for war. Similarly, India's nuclear submarine program is also for the deterrent purpose of the country.

I shall conclude the paper with a positive note. This Seminar title is “India @ 2030: Energy, Economy, Employment.” And on the energy front, we are professing 'Green Energy'. In our nuclear submarine, we are dealing completely with nuclear energy, which emits no toxic and carbon products of greenhouse gases in the atmosphere. Everything in the submarine is done with nuclear energy. The oxygen we generate inside, potable water we make from seawater, cooking, and laundry work a/c for maintaining a clean environment inside; everything is done by the green energy of the nuclear reactor. Above all, moving dynamics also is by nuclear power. Hence, my point is that it is possible to live even on the earth with zero emissions of toxic vapour in the atmosphere.

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# India @ 2030 – What our National Conference aims to Achieve

**- Ashok Adhikary**

Ashok Adhikary graduated from Jadavpur University in 1970 and holds a Post Graduate Diploma in Nuclear Engineering from the Bhabha Atomic Research Center and an Executive Management Diploma from IIM, Ahmedabad. Over the past 40 years, he has worked for BARC, Aker Solutions, Pidilite, Wipro, Tisco, and others. As an enthusiastic advocate of digital technology, he is passionate about the potential that technology and artificial intelligence hold to impact every aspect of human life.

His involvement with the Mumbai Alumni Association goes back over four decades. He is a member of the Jadavpur University Alumni Cell, which seeks to strengthen alumni relationships, improve Jadavpur University's educational infrastructure, and help alumni and their families.

**Introduction**

As we embark on another insightful and engaging conference organised by the Jadavpur University Alumni Association Mumbai Chapter (JUAAM) in 2025, it is imperative to reflect on the journey we have undertaken over the past few years. With a clear vision of India's progress toward 2030, JUAAM has consistently fostered dialogue and deliberation on crucial themes shaping the nation's growth trajectory.

In the previous editions of the series "India @ 2030", we focused on strategic areas that are instrumental to the country's long-term development. These are:

- **Sustainable Development Goals and Business Opportunities** – Addressing how sustainable practices can be integrated with economic growth to create a resilient and inclusive future.
- **Digital Revolution, Industry Disruption & Future of Jobs** – Examining the transformative impact of digitalization, automation, and emerging technologies on industries and employment.
- **Tailing for Sustainable Growth: Reform, Perform, Transform** – Emphasizing the necessity of structural reforms and strategic performance enhancements to drive holistic economic transformation.

**The economy, energy, employment, and what's more?**

This year's theme, 'Energy, Economy, and Employment' or the 3 E's and their inter-dependency, is of paramount importance for India's growth in the near term, say by 2030. Besides these 3 E's, we also need to look into two more E's together for the sustainable growth of our country. These are 'Education' and 'Environment'.

The 3E's (Energy, Economy, and Employment) and 2E's (Education and Environment) will serve as the driving forces behind India's growth, with energy as the catalyst for all economic and social activities. A strong and sustainable energy sector will power industries, stimulate economic expansion, and generate employment opportunities, ultimately improving socio-economic conditions.

Additionally, education will play a pivotal role in fostering innovation, technological advancement, and skill development, ensuring a future-ready workforce. At the same time, a strong commitment to environmental sustainability will help preserve natural resources, safeguard society, and protect Mother Earth for future generations.

To understand the importance of this aspect, we must delve into the current status, set a target to achieve the goals in the near time frame, and the means to achieve the target in each of these 5 E's, and look into their dependency on each other.

Here's a comprehensive growth strategy for India by 2030, focusing on energy, the economy, and employment. In addition, it focuses on their interlinks with education and the environment.

**Energy Sector Initiatives**

To meet the growing energy demand, several key initiatives are being implemented:

- **Renewable Energy Expansion**: Increase the share of renewable energy to 40% of the total energy mix, focusing on solar, wind, and hydroelectric power. This will reduce dependence on fossil fuels and help mitigate climate change.
- **Energy Efficiency**: Implement energy-efficient measures across industries, buildings, and transportation, aiming to reduce overall energy consumption by 20%.
- **Universal Electrification**: Ensure 100% household electrification, with a strong emphasis on rural and underserved areas, improving access to reliable power.
- **Grid Modernization**: Upgrade power grid infrastructure to seamlessly integrate renewable energy sources and ensure a stable, efficient, and reliable power supply across the country.

**India's Economic Growth: Key Drivers and Initiatives**

India's economic growth is expected to be propelled by key sectors such as infrastructure, manufacturing, and services, with a strong focus on achieving the ambitious $5 trillion economy target by 2030. To realize this vision, the government is actively working to increase investment, improve the ease of doing business, and foster entrepreneurship.

Several flagship initiatives are set to accelerate economic growth in the near future:

- **Make in India**: Aims to boost domestic manufacturing, attract foreign and domestic investments, reduce import dependency, and create jobs by strengthening industrial infrastructure.
- **Start-Up India**: Supports innovation and entrepreneurship through financial incentives, tax benefits, and a favourable regulatory framework, fostering a thriving startup ecosystem and economic diversification.
- **Infrastructure Development**: Enhances connectivity and logistics through investments in highways, railways, ports, and urban projects. Initiatives like NIP and Gati Shakti improve transportation efficiency and support industrial growth.
- **Smart Cities Mission**: Drives urban transformation by integrating digital infrastructure, smart services, and green technologies, improving quality of life, attracting investment, and boosting productivity..

**Employment Growth Initiatives**

The initiatives focused on Energy and Economic Growth not only drive industrial and infrastructural development but also play a crucial role in generating employment opportunities across various sectors. A thriving economy leads to increased energy demand, which in turn fuels all-round developmental activities, creating a cycle of sustained growth and progress.

Both the public and private sectors have undertaken significant efforts to boost employment by promoting job creation in manufacturing and services. To ensure a steady supply of a skilled workforce, the government and private enterprises must prioritize skill development and vocational training.

Educational institutions will play a pivotal role in equipping individuals with the necessary skills and expertise to meet industry demands. Strengthening the link between education, industry, and employment will be essential in accelerating India's economic growth and achieving the India @ 2030 vision at the desired pace.

**Interlinkages Between Education and Environment**

Education and environmental sustainability are critical pillars of long-term economic growth, and as previously emphasized, all 5E's—Energy, Economy, Employment, Education, and Environment—are interconnected in shaping India's development. These two domains not only contribute to economic progress but also ensure that growth is sustainable, inclusive, and future-ready.

**Education: Empowering the Future**

To prepare India for the challenges and

opportunities of the future, a robust and future-focused education system is essential. Key focus areas include:

1. STEM Education: Strengthening science, technology, engineering, and mathematics (STEM) education to develop a highly skilled workforce capable of driving innovation and industrial growth.
2. Digital Literacy: Expanding digital literacy programs across all sectors—including finance, healthcare, banking, education, and AI applications—to enhance employability, entrepreneurship, and seamless digital integration in everyday life.
3. Innovation Hubs: Establishing innovation hubs and incubators to foster entrepreneurship, research, and technological advancements, enabling India to become a global leader in emerging technologies.

**The Role of Emerging Disruptive Technologies**

As artificial intelligence (AI), blockchain, genomics, the Internet of Things (IoT), autonomous systems, and virtual reality (VR) take center stage in the global economy, their impact on India's growth cannot be ignored. AI, in particular, is expected to be a transformative force, driving automation, efficiency, and innovation across industries.

However, with these technological advancements come critical challenges:

- Security and safety concerns, particularly with AI-powered autonomous systems and deepfakes.
- Governance and regulatory challenges, as blockchain technology, dark web activities, and IoT vulnerabilities raise ethical and legal issues.
- Societal impact, as critics argue that excessive reliance on VR and AI could blur the lines between the real and virtual world.

It is crucial to deliberate on whether current regulatory frameworks and governance policies are sufficient to harness these technologies for progress while mitigating risks. India must adopt a balanced approach, ensuring that these innovations serve as beneficial tools for economic and social development rather than sources of disruption or harm.

**Environment: A Foundation for Sustainable Growth**

For long-term prosperity, economic growth must align with environmental sustainability. The following strategies can help integrate environmental consciousness into India's development model:

1. Sustainable Development Policies: Embedding eco-friendly principles into economic policies, ensuring growth is not at the expense of natural resources.
2. Climate Change Mitigation: Implementing measures to reduce greenhouse gas emissions, increase energy efficiency, and promote renewable energy sources.
3. Green Infrastructure: Investing in sustainable urban planning, including green buildings, renewable energy-based transportation, and urban forestry, to create resilient cities.
4. Environmental Education: Promoting awareness programs and educational initiatives to instil a culture of environmental responsibility among citizens.

**Implementation Roadmap: A Strategic Approach to Growth**

To ensure a systematic and phased approach to India's economic and environmental goals, I propose the following roadmap:

**Short-Term (2025-2030): Laying the Foundation:**

- Implement economic growth policies to enhance investment, employment generation, and energy security.
- Strengthen digital literacy, AI integration, and innovation-driven education to align with industry needs.
- Launch large-scale renewable energy projects and carbon reduction initiatives.

**Medium-Term (2031-2040): Scaling Up Innovation and Sustainability:**

- Focus on skill development, entrepreneurship, and research-driven education to sustain economic momentum.
- Expand renewable energy adoption, circular economy practices, and carbon-neutral strategies.

- Promote deep-tech innovations, including AI governance frameworks and ethical technology policies.

**Long-Term (2041-2047): Achieving Inclusive, Equitable, and Sustainable Growth:**

- Consolidate gains and ensure economic growth is inclusive and resilient.
- Strengthen global leadership in sustainable energy, green infrastructure, and digital economy.
- Establish stringent environmental policies to maintain ecological balance while continuing technological advancements.

**Conclusion**

A harmonized approach that integrates education, environment, energy, economy, and employment will be crucial for India's progress toward India @ 2030 and beyond. Each of these pillars plays a vital role in driving sustainable and inclusive growth.

Investing in a future-ready workforce will equip India with the skills needed for emerging industries. Adopting sustainable technologies will ensure long-term economic resilience while minimizing environmental impact. Strengthening governance and policy frameworks will promote stability and responsible growth.

By implementing progressive policies and embracing forward-thinking strategies, India can accelerate its transformation. A strong focus on innovation, sustainability, and economic leadership will position the country as a global powerhouse in the decades ahead.

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## Interesting Facts About India's Energy Sector

**1. 3rd Largest Energy Consumer**

India is the third-largest energy consumer in the world, after China and the US, accounting for about 6% of global energy demand.

**2. Rapid Growth in Renewable Energy**

India ranks 4th globally in renewable energy capacity and aims to reach 500 GW of non-fossil fuel capacity by 2030.

**3. Solar Power Boom**

- India has the 5th largest solar installed capacity globally.
- The Bhadla Solar Park (Rajasthan) is the world's largest solar park, spanning 14,000 acres.
- The Kurnool Solar Park (Andhra Pradesh) generates over 1,000 MW, enough to power 7 lakh homes.

**4. Wind Power Leader**

- India is 4th globally in wind energy capacity, with 44 GW of installed capacity.
- The Muppandal Wind Farm (Tamil Nadu) is one of Asia's largest wind farms.

**5. World's Largest Renewable Energy Expansion**

India is executing the largest energy transition by tripling renewable energy capacity by 2030.

**6. Hydropower Giant**

India has over 46 GW of installed hydropower capacity, making it 7th largest globally.

**7. Green Hydrogen Mission**

India launched the National Green Hydrogen Mission to become a global hub for hydrogen production, aiming for 5 million metric tonnes of annual output by 2030.

**8. World's Largest Floating Solar Plant**

India is building the largest floating solar plant in Khandwa, Madhya Pradesh, with a capacity of 600 MW.

**9. Bioenergy & Waste-to-Power Initiatives**

India has over 10 GW of biomass energy capacity, converting agricultural and urban waste into electricity.

**10. Coal Dependency Still High**

Despite renewables growing, coal still contributes 50%+ of India's power generation. India is the 2nd largest coal producer globally.

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# India's 2030 journey : Innovative thinking, cooperation and careful planning are crucial

- Prof Amal Roy

Amal Roy is a Mechanical Engineer& Post Graduate in Industrial Engineering & Management from IIT, Kharagpur with brilliant academic records. In 1968, he graduated from Jadavpur University with a degree in Mechanical Engineering. Having worked for prestigious companies such as ICI, Glaxo, Dabur, Gharda Chemicals, Shreya and others for over 30 years, he has extensive experience in senior positions. He worked for Glaxo as General Manager Logistics, Dabur as Profit Centre Head, Gharda as Director Strategy, and Shreya Life Sciences as Executive Vice President - Supply Chain Management.

He has been teaching for about six years full time and 12 years as a visiting faculty member. His teaching experience includes NMIMS, Jamnalal Bajaj, Sydenham, NITIE, Durga Devi Saraf Institute of Management Studies, IBS Powai, and ITM. Besides publishing technical papers, he also organized industrial seminars, conclaves, and developed case studies. At Durga Devi Saraf Institute of Management, where he served as Chairman of Placement he started an Entrepreneurship Cell. For some time, he served as Chairman, Placement for Durgadevi Saraf Institute of Management, Mumbai. Dewang Mehta Business School Awards Committee awarded him the Best All India Faculty Award for Operations Management.

**Introduction**

India, a nation of over 1.4 billion people, stands at the crossroads of history, envisioning a transformation in the coming decade. As the country looks to 2030, it is poised to harness its potential across three vital sectors: energy, economy, and employment. These pillars will not only shape India's future but also determine its place on the global stage. Let's explore these key areas and their evolving role in New India.

**Energy: The Path to Sustainable Power**

In 2030, India's energy landscape will be vastly different from what it is today. As the world's third-largest emitter of carbon dioxide, India faces significant challenges in balancing energy needs with environmental sustainability. However, the nation is taking ambitious steps to transition towards cleaner energy sources while ensuring that economic growth and energy security remain at the forefront.

Renewable Energy Revolution: India has set a target to achieve 500 GW of renewable energy capacity by 2030, with solar and wind energy playing a pivotal role. The government is actively investing in infrastructure, smart grids, and energy storage to ensure that renewable energy becomes the backbone of India's power generation. The national policy aims for a 50% reduction in carbon intensity (emissions per unit of GDP) by 2030.

Decarbonizing Transport: The transport sector is one of the biggest consumers of energy in India, with a growing number of vehicles contributing to increased pollution. To counter this, the Indian government has rolled out electric vehicle (EV) policies, including incentives for EV manufacturers and consumers, along with an expansion of charging infrastructure. By 2030, India is expected to have a significant portion of its vehicle fleet powered by electricity, further reducing its dependency on fossil fuels.

Energy Access and Efficiency: Despite its rapid development, India still faces challenges in providing consistent and reliable energy access to all. The government's push towards universal electrification, under initiatives such as the Saubhagya scheme, aims to connect every household to the grid by 2030. Additionally, energy efficiency measures through programs like Perform, Achieve, and Trade (PAT) are set to reduce energy

consumption in industries, promoting sustainable development.

India's economy is projected to become the third-largest in the world by 2030, overtaking Japan and Germany, with a GDP crossing $7 trillion. This growth will be fuelled by a mix of innovation, digital transformation, and inclusivity, aiming for broad-based prosperity that reaches even the most remote corners of the country.

**Digital Economy and Innovation:** India's rapidly growing digital economy will be one of the primary drivers of future growth. With a population of over 1 billion mobile phone users and an expanding internet base, digital services are poised to contribute massively to GDP. The government's Digital India initiative is catalysing the development of infrastructure for broadband, e-governance, and digital financial services. The rise of India's tech start-up ecosystem, with unicorns emerging from every corner, will drive innovation and entrepreneurship.

**Manufacturing and Industry 4.0:** India's manufacturing sector, which is central to its ambitions, is undergoing a transformation driven by automation and the adoption of Industry 4.0 technologies. The Make in India campaign, launched to promote manufacturing, will continue to yield results, with sectors like electronics, defence, and automobiles seeing exponential growth. The focus will also be on leveraging artificial intelligence, robotics, and the Internet of Things (IoT) to streamline processes, improve quality, and reduce costs.

**Inclusive Growth:** India's economic growth must be inclusive to ensure it reaches all sections of society. Poverty alleviation programs, the Jan Dhan Yojana (financial inclusion), and social security schemes like Ayushman Bharat are building a foundation for financial equity. Initiatives to promote women's participation in the workforce, empower rural economies, and improve access to quality education will ensure that the benefits of economic growth are shared.

## Employment: A Robust Workforce for the Future

One of the most critical challenges India faces is the creation of sustainable, quality employment for its ever-growing workforce. By 2030, India's working-age population is expected to reach nearly 1 billion, making it one of the youngest nations globally. However, the creation of sufficient employment opportunities, especially in the context of automation, is a key area of concern.

Skill Development and Education: India's National Skill Development Mission (NSDM) is aimed at skilling over 400 million people by 2030. Vocational education, technical training, and partnerships with the private sector will bridge the gap between education and employability. The rise of e-learning platforms, and partnerships with global tech giants to provide cutting-edge training in fields like data science and artificial intelligence, will prepare young Indians for jobs in high-demand sectors.

**Gig Economy and Entrepreneurship:** The gig economy, which employs millions in various sectors such as food delivery, ride-sharing, and digital freelancing, is expanding rapidly. This shift in employment patterns, facilitated by technological platforms, is expected to become a significant feature of India's labour market by 2030. The government's push to support micro, small, and medium enterprises (MSMEs) through financial schemes and ease of doing business reforms is also fostering a culture of entrepreneurship, driving job creation across the country.

Sustainable Jobs and Green Economy: As India moves toward a green economy, new jobs will be created in sectors like renewable energy, electric vehicles, sustainable agriculture, and waste management. These sectors will not only provide employment opportunities but will also support the global push towards sustainability.

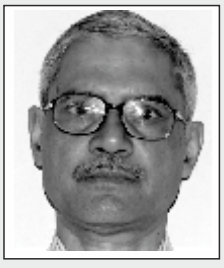
## Conclusion

By 2030, India will emerge as a global leader, powered by innovation, sustainability, and inclusive growth. The country's energy transition will ensure that it is not only energy-secure but also a major player in the global renewable energy market. The economy will thrive on the backs of digital transformation, manufacturing, and inclusivity, while employment opportunities will evolve to meet the demands of a modern workforce. Together, these pillars will help realize the vision of a New India: a nation that is prosperous, sustainable, and a beacon of opportunity for the world.

India's journey to 2030 is marked by transformative change, and while challenges remain, the possibilities are limitless. With careful planning, innovation, and cooperation, India will redefine its future for the betterment of its people and the world at large.

# The path India must follow to become a developed country from an underdeveloped one

- Anup Ghosh



Anup Ghosh graduated in Mechanical Engineering from Jadavpur University in 1970. He moved to Mumbai, working briefly at Calico Chemicals before joining NOCIL Petrochemicals. During his time at NOCIL, he spent two years at Shell Chemicals in Rotterdam (1979-1981). In 1986, he moved to Saudi Arabia to work for National Methanol Company, a SABIC affiliate, in various asset management roles until 1999. In 2002, he joined United Petrochemicals, another SABIC affiliate. There he established a Spare Parts Acquisition Policy and an Inventory System and later served as a Maintenance Specialist. He was involved in establishing the ISO Quality System and worked as an internal auditor for Quality System, PSM, and SHE. His main hobby is reading and writing on technical subjects.

India, at the time of independence in 1947, inherited a struggling economy marked by extreme poverty, a high illiteracy rate, poor infrastructure, and an overdependence on agriculture. The colonial rule had left the country with a weak industrial base, a poorly developed financial system, and widespread socio-economic inequality.

The economy was predominantly agrarian, with frequent droughts and floods causing severe disruptions to agricultural output. The lack of irrigation facilities, modern farming techniques, and grain storage infrastructure resulted in significant food shortages. Furthermore, industrial development was minimal, with most existing industries serving British interests rather than the local economy. India lacked the capital and technical know-how to establish a strong industrial sector, leading to a heavy reliance on imports.

To address these challenges, the Indian government adopted a centrally planned, socialist-inspired economic model that emphasized state-led industrialization, self-sufficiency, and poverty alleviation. The Five-Year Plans, introduced in 1951, focused on large-scale infrastructure projects, irrigation, and heavy industries like steel, machinery, and fertilizers.

Institutions like the Indian Institutes of Technology (IITs) and national research laboratories were established to create a skilled workforce and drive innovation. However, the License Raj system, which controlled industries through a complex web of permits and regulations, hindered private sector growth and limited economic expansion.

In 1991, economic liberalization marked a turning point, introducing market-oriented reforms that dismantled trade barriers, encouraged foreign direct investment (FDI), and promoted private enterprise. The impact was transformative, leading to high GDP growth rates, the rise of India's IT and services sector, and increased global integration.

Today, India stands as the fifth-largest economy globally, with an ambitious goal of becoming a $10 trillion economy by the first half of the next decade, only behind the United States and China. This paper examines India's economic evolution, key growth drivers, policy reforms, energy transition, employment dynamics, and challenges on its path to becoming a developed nation.

## Economic Growth and Structural Transformation

### Early Economic Policies (1947-1991): The Planned Economy Approach

The first three decades post-independence were marked by state-led industrialization under the Nehruvian socialist model. Key features included:

1. Agricultural and Irrigation Development: Large-scale irrigation projects such as the Bhakra Nangal Dam improved water availability for agriculture. However, poor agricultural productivity persisted due to outdated techniques.
2. Public Sector Expansion: The government

established BHEL, SAIL, and ONGC to drive industrialization in sectors requiring heavy capital investment.

3. Import Substitution Industrialization (ISI): To reduce foreign dependency, India focused on self-reliance by restricting imports and encouraging domestic production.
4. Educational and Research Institutions: Establishment of IITs, IIMs, AIIMS, and CSIR laboratories to create an educated workforce and research ecosystem.

Despite initial success, slow economic growth (Hindu Rate of Growth ~3.5%), bureaucratic inefficiencies, and the License Raj resulted in stagnation, fiscal deficits, and balance of payments crises by the late 1980s.

**Economic Liberalization (1991-Present): Market-Oriented Reforms**

The 1991 economic crisis, triggered by a foreign exchange shortage, forced India to undertake structural reforms under IMF guidance:

- Deregulation of Industries: Privatization and disinvestment of state-owned enterprises allowed market competition.
- Trade Liberalization: Reduction of import tariffs, easing of FDI restrictions, and removal of export barriers led to global integration.
- Financial Sector Reforms: Modernization of RBI policies, the introduction of SEBI, and the rise of private banking institutions.

This transition propelled high GDP growth (6-8% annually), the rise of India's IT sector, and significant improvements in global competitiveness.

## Key Growth Drivers of the Indian Economy

**1. Demographic Dividend: The Young Workforce**

India has the world's largest youth population, with over 65% below the age of 35. This demographic advantage, if properly harnessed, can significantly boost economic growth. However, for sustained productivity, investment in education, skill development, and employment generation is essential.

**2. Technology and Innovation: The Digital Economy**

India's rise as a global technology hub is driven by cities like Bengaluru, Hyderabad, and Chennai. The IT sector contributes 7.5% to GDP, with exports exceeding $200 billion in 2023. Government initiatives such as Digital India, Startup India, and Make in India are fostering a thriving tech ecosystem.

**3. Infrastructure and Urbanization**

India is undergoing rapid urbanization, with the urban population expected to reach 40% by 2030. Major projects driving this transformation include:

- Delhi-Mumbai Industrial Corridor (DMIC) – connecting production hubs with global markets.
- Smart Cities Mission – promoting modern urban planning, waste management, and digital governance.
- High-Speed Rail (Bullet Train Project) – enhancing transport efficiency.

**4. Manufacturing and Export Growth**

The “Make in India” initiative is positioning India as a global manufacturing hub, particularly in electronics, electric vehicles (EVs), and pharmaceuticals. Key achievements include:

- India is now the second-largest smartphone manufacturer globally.
- EV production surged by 300% in the last five years.
- Pharmaceutical exports grew to $27 billion in 2023, making India the "Pharmacy of the World".

**5. Green Energy Transition and Sustainability**

India is aggressively shifting toward renewable energy to reduce dependence on fossil fuels:

- Solar power capacity: 96 GW in 2024 → 280 GW by 2030.
- Wind power: 47.2 GW → 140 GW.
- Green hydrogen production target: 5 million metric tonnes by 2030.
- Nuclear energy expansion: 8.18 GW → 14 GW by 2030.

This shift will lower energy costs, enhance energy security, and cut carbon emissions.

## Challenges and the Road Ahead

**1. Employment and Workforce Transition**

- Sectoral distribution: 45% in agriculture, 11.4% in manufacturing, 29% in services.
- Gig economy growth: Over 29.5% of workers are engaged in informal or platform-based work.

- Female workforce participation: Increased from 23.3% (2017) to 37% (2022), especially in rural areas.

To sustain job creation, India must enhance skilling programs, implement labor reforms, and promote flexible work models.

**2. Global Risks and Economic Stability**

India's economic trajectory is influenced by:

- Geopolitical tensions (China, Middle East conflicts).
- Supply chain disruptions (post-COVID, semiconductor shortages).
- Climate change risks (floods, heatwaves affecting agriculture).

Strategic foreign policy, economic resilience, and environmental policies will be critical in mitigating these risks.

## Conclusion

India's transition from an underdeveloped economy to a potential global powerhouse is well underway. The country's young population, digital revolution, strong manufacturing base, and sustainability focus will drive future growth. While geopolitical uncertainties, employment challenges, and economic fluctuations pose risks, strategic governance, continuous reforms, and technological advancements will keep India on its path to becoming the third-largest economy by 2030. With a combination of visionary leadership, strong policymaking, and global integration, India is poised for a transformative future.

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## Current Employment Scenario (2024-25)

**1. Total Workforce**
- ✦ 530+ million people are part of India's workforce.
- ✦ Labor force participation rate (LFPR): ~50%, lower for women (~30%).

**2. Sector-Wise Employment Share**
- ✦ Agriculture: 43% (declining but still the largest employer)
- ✦ Industry & Manufacturing: 25% (rising due to "Make in India")
- ✦ Services: 32% (biggest contributor to GDP, includes IT, BFSI, healthcare)

**3. Unemployment Rate**
- ✦ National unemployment: ~6-7% (varies across regions & education levels).
- ✦ Urban areas: Higher unemployment due to skill mismatch.
- ✦ Rural areas: Seasonal unemployment still prevalent.

**4. Informal Sector Dominance**
- ✦ Nearly 80% of India's workforce is in the informal sector, lacking job security and social benefits.

**5. Gig Economy & Freelancing Growth**
- ✦ India has the 2nd largest gig workforce (~15 million gig workers).
- ✦ Sectors like ride-hailing, delivery services, and online freelancing are booming.

**6. Tech & IT Industry Driving Growth**
- ✦ Over 4.5 million people employed in IT & software services.
- ✦ AI, cloud computing, and cybersecurity are emerging job sectors.

**7. Manufacturing Jobs Expanding**
- ✦ PLI schemes (Production Linked Incentives) in electronics, semiconductors, and EVs are driving job creation.
- ✦ India is set to become a global manufacturing hub, increasing demand for skilled workers.

**8. Women's Employment Challenges**
- ✦ Female labor force participation rate (FLFPR) remains low (~30%) but is rising in urban & formal sectors.
- ✦ WFH and hybrid models post-pandemic have improved participation.

**9. Youth Unemployment & Skill Gap**
- ✦ Unemployment is high among graduates due to lack of industry-ready skills.
- ✦ National Skill Development Corporation (NSDC) aims to train 400 million workers by 2030.

# Towards realizing India's Semiconductor Mission

- Shyama Prasad Ray

Shyama Prasad Ray earned a Bachelor of Engineering degree in Instrumentation and Electronics Engineering from Jadavpur University after completing his physics degree at Calcutta University in 1967. He is also a Fellow of the Institution of Engineers India.

His career has spanned numerous prestigious organizations, including BARC Trombay, Blue Star Ltd, Petrokemya Saudi Arabia, Technipetrol Rome, Tata Honeywell Pune, Toyo Engineering India Mumbai, Chemtrol Engineering, and Aker Solutions. At Toyo, he was the Engineering in charge of Haldia Petrochemicals and MRPL Refinery and petrochemicals Phase I and Phase II, the Project in charge of the refinery at Petrobras Brazil, and the tank farm revamping project of BPCL Mahul. He played a crucial role in the development of the world's first commercial Butene-1 plant at Petrokemya Saudi Arabia and the Iso butyl Benzene plant of Vinati Organic Ltd at Mahad India.

After retiring, he dedicated himself to ancient Indian spiritual and literary scripts. He is an avid enthusiast of Indian classical music and a prolific writer on diverse subjects, currently residing in Mumbai. His book, 'Seen Felt and Faced Unlimited', is widely circulated.

The Indian Semiconductor Mission, launched on December 15, 2022 aims to establish a robust semiconductor ecosystem in India. This mission, housed under the Digital India Corporation, projects several schemes to rejuvenate the semiconductor industry in India. These schemes include incentives for semiconductor manufacturing, support for research and development, and initiatives to attract global semiconductor companies to set up operations in India. The mission also focuses on skill development and capacity building to create a skilled workforce for the semiconductor industry. Additionally, the mission aims to promote collaboration between industry, academia, and government to drive innovation and growth in the semiconductor sector.

Digital India Corporation Initiatives includes the following scheme:

1. **Setting Up Semiconductor Fabs in India**: Provides fiscal support to eligible applicants for establishing semiconductor fabrication facilities, aiming to attract significant investments.

2. **Setting Up Display Fabs**: Offers fiscal support for setting up TFT LCD/AMOLED-based display fabrication facilities, targeting large investments.

3. **Compound Semiconductors, Silicon**

- Foundry at 2500°C to extract silicon metal.
- Wafer preparation.
- Pattern transfer.
- Doping.
- P-type substrate wafer.
- Thermal oxidation.
- Photolithography.
- Oxide etching.
- N-type chalcogenide by ion implantation.
- Thermal oxidation.
- Gate photolithography.
- Gate oxide etching.
- Metal deposition.
- Metal contact photolithography.
- Metal etching.
- Final devices.

| | |
|---|---|
| • Stable power supply.<br>• Vibration-proof building.<br>• Dust-free environment with controlled humidity.<br>• Liquid and gas disposal system.<br>• Proper drainage and sewerage.<br>• High-quality water treatment plant. | • Skilled, dedicated workforce.<br>• Flood-proof area.<br>• Excellent communication facilities.<br>• Law and order maintenance.<br>• Reliable supplier network for chemicals and gases.<br>• Liquid waste treatment & safe disposal. |

**Photonics, and Sensor Fabs**: Includes support for compound semiconductors, silicon photonics, sensor fabs, and semiconductor ATMP/OSAT facilities.

**4. Fiscal Support for Compound Semiconductors and Sensor Fabs**: Provides 30% of capital expenditure to eligible applicants for setting up compound semiconductors, silicon photonics, sensor fabs, and semiconductor ATMP/OSAT facilities in India.

**Robust planning and implementation mechanism :**

The history of semiconductor material development is a vast study in physics, chemistry, metallurgy, material science, and process technology. It involves extracting silicon metal from silicon-rich sand, crucial for modern electronics. Thanks to scientists and technologists who overcame hurdles with years of research and innovation.

**Major processing steps for chip production :** Sourcing equipment involves significant effort and investment due to closely guarded technology and high costs. There are following challenges in establishing fabrication facilities:

**Important steps to become a Semiconductor Nation :**

Significant actions by several Indian participants aim to transform India into a self-reliant nation in the semiconductor industry. While only a few major players have shown keen interest and committed to substantial investments, the pioneering venture is led by the Tata Group.

The inaugural semiconductor chip from the joint venture between the Tata Group and Taiwan's Power chip Semiconductor Manufacturing Corporation (PSMC) is expected to debut by the end of 2026. PSMC chairman Frank Huang mentioned in an interview with The Economic Times on March 13, 2024, that specifics of the partnership with the Tatas are still being finalized. “At the moment, we have decided to work out the technology transfer. Later, we can talk about investment,” he said.

The semiconductor fab is being established in Gujarat's Dholera, with the Centre and state governments expected to subsidize up to 70% of the project's $1.1 billion cost.

Additionally, the government of India approved two more semiconductor units: the Tata Semiconductor Assembly and Test Unit in Assam and the CG-Renesas Electronics-Star Microelectronics joint venture in Sanand, Gujarat.

The cumulative investments in these three semiconductor units will amount to Rs 1,26,000 crore. Major investments committed or proposed include:

- Tata Group in Gujarat: Rs 91,526 crore.
- Tata Group in Assam: Rs 27,120 crore.
- Micron in Gujarat: Rs 22,516 crore.
- Kayanes in Gujarat: Rs 3,307 crore.
- Tower Group of Israel and Adani in Maharashtra: Rs 83,974 crore.
- CG Power in Gujarat: Rs 7,584 crore.
- Vedanta Group is another proposed investor.

**Support from world's leading technology groups:**

There are more than 21 technology groups contributing to the support of this huge semiconductor industry in India in various ways, as

enumerated below:

- **Micron Technology**: Produces memory and data storage solutions.
- **AMD**: Develops processor graphics and adaptive system-on-chips, investing $400 million in India by 2028.
- **NXP**: Designs semiconductors for automotive, mobile, and industrial sectors, employing 2500 engineers across India.
- **Samsung Semiconductor** : Bangalore R&D office designs processors and memory storage solutions.
- **MOSCHIP** : Hyderabad-based, with over 30 semiconductor designs and 1300 engineers.
- **Applied Materials** : Specializes in material engineering for semiconductors, based in Bangalore.
- **Broadcom Inc**: US-based, produces telecom semiconductors, valued at $37 billion in 2015.
- **Microchip Technology**: Invests $300 million in embedded control solutions across Bangalore, Chennai, and Hyderabad.
- **ASM Technologies**: Advises on wafer materialization and packaging, based in Bangalore.
- **Chip Logic Technologies**: Offers semiconductor IP blocks for custom silicon solutions, based in Bangalore and the UK.
- **Sankalp Semiconductors**: Designs semiconductors for various industries, now part of HCL Technologies.
- **CDIL**: Introduced silicon semiconductor tech in India, produces 699 million items annually.
- **Wipro Ltd**: Over 30 years in semiconductor design, holds 35 patents, and has delivered 250 ASICs.
- **SPEL Semiconductors**: India's only assembly and test facility for ICs, acquired by Natronix in 2014.
- **NVIDIA**: Develops GPUs, processors, and AI supercomputers, with over 3800 employees in India.
- **Intel Corporation**: Develops processors for AI and high-performance computing, with 14,000 workers in India.
- **Qualcomm**: Develops 5G processors, employs 16,000 people, and partners with Tata Group.
- **Marvell**: Designs semiconductors for data infrastructure and has a large office in Bangalore.
- **Tata Group**: Plans to open a semiconductor fabrication plant in Gujarat.
- **Sankhya Lab**: India's first fabless semiconductor company, developing SDR chipsets.
- **ARM**: Develops GPU, CPU, and NPU designs, used in over 270 billion chips globally.

**Indian semiconductor sector to create 1 million jobs :**

In light of the above, we can expect India to enter the semiconductor industry soon. Currently, India lags behind other nations that have pioneered semiconductor technologies through continuous R&D and advancements. However, India's strength in the software field will eventually drive a new revolution in the country. India must continue to invest heavily in R&D and further advancements to remain competitive in this field.

The Indian semiconductor industry is expected to reach $109 billion by 2030, according to the Indian minister of state for electronics and information technology. This growth bodes well for India's aspirations of self-reliance and economic advancement. Major industrial groups in India are showing renewed interest and optimism in investing in the semiconductor industry.

If the geopolitical global status remains stable, there is every reason to believe that despite India's current lagging position in this sector, it will continue to leapfrog in the coming decades and gain visibility in major industrial countries worldwide. It is estimated that this growing sector will generate direct and indirect employment for approximately 1 million people by the end of 2026 according to a report by talent solutions company NLB Services.

# Sustainable Growth vs. Resource Exploitation : The Dilemma of India's Economic Future

**Lalit Kumar Singhania**

Mr. Lalit Kumar Singhania is a graduate in Agriculture & Animal Husbandry who has specialised in Mechanized farming. He has developed an energy efficient and clean process to produce steel from low grade iron ore. He has been honoured with awards for introducing several innovations in the steel industry. He holds a patent for his unique flue gas cleaning system for reducing Particulate Matter from flue gases. He was associated with waste heat recovery based power plants, Bio Mass power projects, Wind Power systems and Solar Energy Power projects registered with UNFCCC-CDM-EB. He has more than 25 years' experience in preparing EIA reports conforming to the various notifications.

Lalit Kumar Singhania is the editor of Paryvaran Urja Times, a monthly Hindi magazine that has been published since 1998.

India is one of the fastest-growing economies in the world. The country has made remarkable progress in the last few years with an unwavering commitment to economic expansion. The national government has set an ambitious target of making India the third-largest economy in the world, and every effort is being made to turn this vision into reality.

However, as an environmentalist and sustainable development expert, I see three critical barriers to achieving this goal sustainably:

1. Exploding population growth
2. Rising per capita resource consumption
3. The finite nature of Earth's natural resources

Without addressing these challenges—particularly population control—India's economic trajectory is likely to become unsustainable.

**The Paradox of Modern Economic Growth: A Resource-Intensive Model**

The prevailing economic model is inherently resource-driven—whether natural or synthetic, economic growth demands continuous resource extraction and consumption. Increased consumption fuels demand, necessitating higher production, which in turn requires more land, water, minerals, and fossil fuels.

Most modern economists have emphasized population growth as an essential driver of economic expansion. The logic is straightforward:

- A larger population means higher demand for goods and services.
- Increased demand fosters higher production and greater employment opportunities.
- Economic growth leads to higher per capita income and improved living standards.

However, this equation fails to account for the environmental costs of resource depletion. The global economy ignores the financial burden of deforestation and loss of fertile land; destruction of biodiversity; air, water, and soil pollution and, rising healthcare costs due to environmental degradation.

The unsustainable nature of our economy is best illustrated by Earth Overshoot Day—the date when humanity's resource consumption exceeds Earth's ability to regenerate those resources within a year.

In 2024, Earth Overshoot Day fell on August 1st, meaning that in just seven months, we had consumed a year's worth of natural resources. For the remaining five months, humanity lived on ecological credit.

Despite these hidden economic losses, our financial systems do not assign negative values to environmental destruction. GDP calculations overlook the cost of ecosystem damage, falsely presenting economic growth as a net-positive phenomenon.

**Economic Growth vs. Environmental Collapse: The Price of Development**

India's rapid urbanization and industrial expansion have put immense pressure on natural resources. Every sector—from agriculture and mining to energy and infrastructure—is dependent on environmental exploitation.

The Cost of Increased Energy Demand

The global demand for energy is rising exponentially, fueled by industrialization and modern lifestyles.

However, this has led to:

- Unprecedented greenhouse gas (GHG) emissions
- A 1.5°C increase in global temperatures in 2024 alone
- Extreme weather events, such as Floods in Spain, Hurricanes in Florida, USA, Droughts in multiple regions and Wildfires in Los Angeles, California

The direct cause of these disasters? Uncontrolled carbon emissions, deforestation, and unsustainable land use.

GHG Emissions and Climate Instability

According to 2023 data, the top global polluters—China, the USA, India, the EU, Russia, and Brazil—accounted for 62.7% of global GHG emissions. Global $CO_2$ concentration has reached 472 ppm. Also, the total GHG emissions in 2023 were 53 gigatons—driven primarily by energy consumption.

Despite this, no major world leader or organization, including the United Nations, is willing to confront the fundamental issue: population growth and resource overconsumption are pushing the planet beyond its limits.

**The Population-Resource Crisis: Ignored by Economists and Politicians**

In 1800, the global population was under 1 billion. By 2024, it has reached 8.2 billion and is projected to hit 9.7 billion by 2050. India alone has a population of 1.46 billion, accounting for 17.8% of the world's total.

Many policymakers ignore the direct link between population growth and environmental destruction. Even the wealthiest nations cannot provide food, shelter, and employment without massively exploiting natural resources.

Real GDP (constant prices) for 2024-25 is projected at ₹184.88 lakh crore, up from ₹173.82 lakh crore in 2023-24. India's unemployment rate stands at 7.8% (September 2024) despite a higher employment rate. Income disparity is growing—the rich consume disproportionately more resources, worsening environmental degradation.

The fundamental flaw in our economic model is that growth is pursued at the cost of future generations. We are consuming resources today that should have lasted for centuries.

**The Way Forward: Rethinking Economic Growth for a Sustainable Future**

1. Transition from a Consumption-Driven Economy to a Conservation-Based Model

A sustainable economy must prioritize resource efficiency and ecological balance rather than relentless consumption. This shift requires:

- Circular economy policies that minimize waste and maximize resource use.
- Green taxation that imposes environmental costs on excessive consumption.
- Decarbonization of industries to reduce GHG emissions.

2. Controlling Population Growth

Economic sustainability is impossible without population stabilization. Policymakers must:

- Implement aggressive family planning initiatives.
- Incentivize lower birth rates through education and healthcare programs.
- Redefine economic success beyond population-driven consumption.

3. Reforming Carbon Accounting in GDP

Current GDP calculations fail to reflect environmental degradation. We must:

- Integrate natural capital accounting into economic frameworks.
- Assign monetary value to ecosystem services (clean air, water, biodiversity).
- Penalize industries with high environmental footprints.

4. Investing in Renewable Energy with Minimal Carbon Footprint

India must commit to clean energy expansion while ensuring that:

- Renewable energy infrastructure is truly sustainable (not just shifting emissions elsewhere).
- Transition plans account for employment shifts from fossil fuel industries.
- Energy efficiency is prioritized over raw expansion.

**Conclusion: Can India Lead the World in Sustainable Development?**

The world is trapped in a paradox—economic growth depends on increasing consumption, but unrestricted consumption threatens long-term survival. Without urgent intervention, the fragile balance of Earth's ecosystems will collapse.

India must break away from the unsustainable models of Western industrialization and lead the way in eco-economic innovation. Green GDP, population control, and conservation-driven policies must be at the heart of our strategy.

Ultimately, real progress is not measured by GDP growth alone, but by the well-being of people and the planet. The choice is ours—will we continue down the path of reckless exploitation, or will we take bold steps toward a truly sustainable future?

★ ★ ★

# A Demographic Analysis of Employment in India

- Kinara Goyal

Kinara Goyal is a student at Chatrabhuj Narsee School, Mumbai, where she is in 7th grade. She has self-published several short stories and articles on many subjects on her blog, Kid's Bouquet. She also reviews books and writes about places she has travelled. Playing with her little sister, reading, and creating art are some of her favorite things.

Her article analyzes the demographic dividend in India from 2005 to 2055 based on existing datasets. Additionally, the article studied workforce trends, disparities, and the need to diversify employment into manufacturing and construction. According to Kinara, sustainable economic growth depends on leveraging the demographic dividend.

## INTRODUCTION

India is at a critical point in its development. It is facing an unemployment crisis. With the nation's demographic dividend reaching its peak, policymakers need to use the labor force better by reducing unemployment.

The unemployment rate was 8.5% in August 2024, a high since 2020-21, according to the Center for Monitoring the Indian Economy (CMIE). However, the Periodic Labor Force Survey (PLFS) conducted by the government paints a different picture, showing a decrease in the unemployment rate from July 2022 to June 2024. This highlights the challenges in accurately capturing employment data and emphasizes the need for consistent and reliable metrics. This paper will explore why these two metrics produce such different results.

Protests have broken out across India recently, highlighting the severe unemployment crisis. In 2024, violent protests broke out in Bihar and Uttar Pradesh over alleged flaws in government job recruitment processes. Demonstrations also occurred in major cities like Delhi, Mumbai, and Kolkata, reflecting widespread anger regarding the rising unemployment rates.

An International Labor Organization (ILO) report reveals that 83% of unemployed Indians are youth. The proportion of educated youth among the unemployed nearly doubled from 35.2% in 2000 to 65.7% in 2022.

## CURRENT EMPLOYMENT DEMOGRAPHIC

An employment demographic is a compilation of data encompassing various aspects of the employment sector, such as unemployment rate, gender ethnicity, age, and educational qualification-based distribution of employment, wealth and income, labor force participation rate, type of employment, etc. This data offers insight into the employment sector of an economy.

*A. Defining Unemployment*

The International Labor Organization (ILO) definition of an unemployed individual is:

- a person over fifteen years of age who
- having actively sought employment in the last four weeks OR having found a job that will start in more than three months;
- is unemployed during the reference week;
- and can take a job within two weeks.

*B. Recent Employment Trends*

| Unemployment Data | | |
|---|---|---|
| Year | CMIE | PLFS |
| 2016-17 | 7.4% | 3% |
| 2017-18 | 4.3% | 6% |
| 2018-19 | 6.3% | 5.8% |
| 2019-20 | 7.5% | 4.8% |
| 2020-21 | 8.8% | 4.3% |
| 2021-22 | 7.7% | 4.1% |
| 2022-23 | 7.6% | 4.2% |
| 2023-24 | 8.0% | 3.2% |

Fig. 1. Table depicting unemployment data from CMIE and PLFS

There is obviously a major discrepancy between CMIE and PLFS data. Let's look into why this could be.

During the pandemic, many people were incapable of searching for work and many who had actively tried gave

up hope. This effect is called the 'discouraged worker effect'. As per the ILO definition, to be unemployed one must actively seek work, so this effect lowers unemployment numbers. This is why PLFS measured a decrease in unemployment in the fiscal year 2020-202.

Additionally, PLFS uses the Usual Status to determine whether or not people are employed. Any person working for more than six months is considered employed. To be considered employed, a person must have worked at least one hour a day for at least 183 days in the last 365 days.

This measure is not meaningful in heavily agrarian economies like India, as a large fraction of employment is seasonal and often informal, resulting in a non-steady source of income. This renders the PLFS data particularly inaccurate during the lockdown in 2020, which only spanned part of the year. If someone was engaged in work for part of the year during which they did not face lockdown, they were considered employed.

India, being an agrarian economy, needs most of its employment during the sowing and harvesting season. As Table II shows, the 2020 lockdown, which occurred between 24 March 2020 and 31 May 2020, only affected the harvest of the rabi crop, indicating it had little impact on unemployment in the country.

| Crop Seasons | | |
|---|---|---|
| Crop | Harvest | Sow |
| Kharif | September-October | June-July |
| Rabi | October-November | March-April |
| Zaid | March-May (mostly April) | June |

Fig. 2. Table depicting seasonal employment in the agricultural sector

Meanwhile, CMIE data shows a sharp increase in unemployment during the first year of the pandemic - from 7.5% to 8.8%, because CMIE measures employment using the Current Weekly Status (CWS) and the Usual Status.

The CMIE method of measuring unemployment classifies a person who did not do eight hours of work in a day as unemployed for that day. After sampling all 365 days of the year, they take the average of the number of employed and unemployed days. If the average is employed days, then the subject is considered employed. If the opposite is true, the subject is considered unemployed.

This definition usually yields higher unemployment numbers in India, because employment opportunities vary significantly over different weeks of the year.

The following two anecdotes indicate that the CMIE definition of unemployment is more meaningful for gaining insight into the employment situation in India.

In September 2024, thousands of students protested in Himachal Pradesh, because, despite investing in higher education, students could not find jobs. In Himachal Pradesh, nearly 8 lakh people are unemployed.

Another news report claimed that 1800 people applied for 10 jobs, indicating rising unemployment rates.

An increase in unemployment causes distress on an individual scale and is a waste of human resources on a national one. However, unemployment in general is not the most problematic issue. The number of youth has been growing in the last few years, and many of India's youth are unable to find jobs they are satisfied with.

### *C. Youth Unemployment*

Youth unemployment makes up about 83% of total unemployment. The CMIE data places it at a staggering 45.4%, and it has been steadily on the rise since 2017.

According to the ILO, report youth unemployment in India for illiterates is 3.4%, and for people who have completed a secondary or higher level of education, it is 18.1%. For graduates exclusively it is 29.1%.

On the other hand, a survey of multinational companies revealed that even students graduating from the top colleges are often ill-equipped to handle the existing available jobs, due to improper or inadequate training and education in their specialized fields, thus aggravating the youth unemployment issue.

Making jobs available in the energy sector, particularly focusing on renewable energy could be an excellent way to tackle this problem. Jobs in manufacturing are of increased interest currently, and leveraging the young workforce to increase self-sufficiency in the energy sector and reduce the carbon footprint could be India's best method to tackle the unemployment situation. Particularly, expanding the number of jobs in the hydrogen industry will achieve all three of these goals. It already produces 6 million metric tonnes per annum(Mtpa), which has rapidly grown since 2023.

18 million children hit working age every year. To provide jobs to the expanded workforce, the government must create nearly 18 million jobs each year in sectors of interest.

### *D. Sector-wise Job Distribution*

India has one of the world's largest service industries. Dominance over any industry strengthens the position of a country in an international forum.

On the downside, a high concentration of service employees leaves fewer recruits for the construction and IT industries, resulting in inadequate and poor-quality infrastructure. The manufacturing sector too in India was underdeveloped, crippling our production and resulting in a high dependence on imports as well as a sub-optimal export income. Earlier not many people wanted jobs in these sectors, as most of the workforce was already employed in agriculture. However, although now people are willing to take these jobs, they do not exist in adequate numbers.

Also, although a job in services is a relatively high-pay job in India, individual advancement in service-based jobs, is limited. These jobs allow for minimal career growth through learning and experience and therefore offer minimal pay raises, diminishing the country's potential for increased income inflow.

Manufacturing accounts for 38.5% of India's non-agricultural workforce, and IT even less, demonstrating that the shift from agricultural dominance in the Indian economy has been leaning towards services.

***E. Labor Force Participation Rate***

The labor force participation rate is the number of people in work divided by the number of people of working age, whether employed, unemployed, or not actively seeking employment.

The Labor force participation rate according to PLFS data is 60.1% from June 2023 to July 2024. According to CMIE data, it is 40.2%. This discrepancy arises due to the seasonal nature of employment in the agricultural sector. During harvesting and sowing the farm needs more labor than the rest of the year. So, many farm laborers are out of work and lack a steady income source during late winter and some other parts of the year.

At the same time, agricultural workers often do not actively look for jobs, because they know they will be employed again in the harvesting season. PLFS analyses data every year, as it follows Usual Status, whereas CMIE which uses Current Weekly Status analyses weekly data and calculates the average of the 52 weeks of the year. That is why there is such a large discrepancy in labor force participation rate data from these two sources.

A low labor force participation rate is detrimental to an economy. At 39.5%%, India's labor force participation rate is one of the lowest in the world. An inactive labor force slows infrastructural development and the growth of the industrial sector. This growth is necessary for the advancement of developing countries.

One factor contributing to the low labor force participation rate in India is the lack of jobs in the appropriate sector. As more people receive a higher education in India they want jobs in IT and manufacturing. However, currently, the government has failed to create jobs in these sectors, instead creating new ones in agriculture. This mismatch between job demand and availability needs to be addressed to improve the employment situation in India.

Reallocating government expenditure and investments into appropriate sectors to generate high-paid jobs, that make higher education a worthwhile investment will not only improve labor force participation in India but help develop the country's infrastructure and IT sector thereby strengthening its economy.

***F. Average Income Per Annum***

The average income per annum in India is 384,000 INR, which is significantly lower than the Asia-Pacific Average of almost 1,703,832 INR. This discrepancy is due to the large number of workers in the informal sector and India's agrarian economy.

India's most qualified graduates leaving to find better prospects in the United States or Europe is also a contributing factor. This severely hemorrhages government funding and wastes resources. The exodus of India's most talented and skilled workers stunts and slows the development of high-tech industries within the country.

***G. Wealth Distribution***

The richest 1% of taxpayers in India own over 40% of the nation's assets. The richest 0.001% of the nation's taxpayers enjoy the same wealth as the bottom 50%. The number of middle-income taxpayers has significantly reduced since 2018-19. The top 1% of earners earn over 23 times the average earner. India was ranked 77 on the Gini coefficient scale.

This skewed distribution of wealth shows that irrespective of the per capita GDP, most of India's population remains very poor. Rigorous implementation of minimum wage and fair pay laws across genders and communities could help improve wealth distribution.

## INDIA'S DEMOGRAPHIC DIVIDEND

A demographic dividend is a situation where the ratio of working-age people to dependents is greater than 1, meaning most people in the country are eligible to participate in the workforce. It was long believed that the rising and falling birth rates were a cycle. However, this theory has been discredited, and it is believed that a civilization goes through only one demographic dividend before it begins to decline.

### *A. Importance of a Demographic Dividend*

India's demographic dividend began in 2005 and is expected to last another 30 years. In 2030, the demographic dividend will be at its peak. It's important to make the most of the demographic dividend to expedite development and usher in prosperity. Besides, squandering the demographic dividend to achieve sub-optimal growth can have catastrophic effects culminating in a stagnant economy incapable of supporting a larger senior citizen population with a smaller workforce in the next generation.

A researcher, Dr Sridhar Krishna of the Takshashila University, estimated that the Indian government needs to create at least 20 million jobs a year to make effective use of the demographic dividend – 18 million for the youth that join the workforce every year, and 2 million for the existing inactive or unemployed eligible workers.

### *B. Optimal Use of the Demographic Dividend in India*

Newly created jobs need to focus on expanding the manufacturing and construction industry, to promote robust growth through developing quality infrastructure in the nation. Such jobs should also be more enticing than agricultural work, for the educated and qualified youth entering the workforce yearly.

Another major reason to divert investments towards creating employment opportunities in manufacturing and high-tech industries is over-employment in the agricultural sector. Nearly 43% of workers are employed in agriculture – yet agriculture only contributes to 15% of India's GDP. This misuse of labor hampers the productivity and development in other more lucrative sectors.

The most effective way to make use of the demographic dividend is to mitigate the unemployment crisis we are facing now and to create jobs that support both individual career growth, as well as the long-term prosperity of the nation.

Jobs in the energy sector, particularly the budding green hydrogen industry could be one of the optimal areas to create jobs. These jobs, which are not in agriculture, but manufacturing will attract the interest of the Indian youth. It will allow for sustainable development. This is an excellent use of resources from a national perspective. The development of this sector will increase India's self-sufficiency as it will no longer be reliant on external sources for energy.

## CONCLUSIONS

Unemployment in India is rising, which can cause nationwide unrest.

Youth unemployment, among the educated, is higher than among the uneducated, highlighting a pressing issue. Redirecting government funds from colleges to job creation initiatives could be more effective in addressing these challenges.

To leverage India's demographic dividend, creating jobs in sectors where employment is sought after, is essential.

Increasing labor force participation, especially among women and youth is necessary. The government should focus on creating jobs in the IT and manufacturing sectors, which have high returns for the economy. People prefer these jobs to agricultural ones.

India needs to shift its focus from the services sector to the manufacturing, construction, and IT sectors. This will help support the economy in the future and make effective use of the demographic dividend.

Additionally, improving wealth distribution is vital. Addressing income inequalities will ensure that economic growth benefits all sections of society, leading to a more equitable and just economy.

Diverting current unemployed labor to the energy sector, particularly in green hydrogen and renewable energy could improve the current employment situation, reduce India's carbon footprint and reduce our external dependence on oil.

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## Interesting facts about the Indian economy

**Startup Ecosystem – 3rd Largest in the World**

India has over 100,000 startups and 100+ unicorns (valued at $1B+), making it the 3rd largest startup ecosystem after the US and China.

**Manufacturing & Make in India Growth**

India aims to become a manufacturing hub with initiatives like Make in India & PLI schemes, boosting electronics, automobiles, and semiconductors.

**Largest Consumer Market**

India's growing middle class (400+ million people) makes it one of the biggest consumer markets in the world, driving demand for everything from smartphones to luxury goods.

**Renewable Energy Giant**

India ranks 4th in the world in renewable energy capacity, with ambitious plans to reach 500 GW of non-fossil fuel capacity by 2030.

**World's Biggest Gold Consumer**

India is the largest consumer of gold, with Indians buying 800-900 tonnes of gold annually, driven by weddings, festivals, and investment.

**Agriculture Powerhouse**

India is the largest producer of milk, pulses, and spices and the 2nd largest producer of wheat, rice, and fruits.

**Largest Exporter of Pharmaceuticals**

India is known as the "Pharmacy of the World", supplying over 50% of global vaccine demand and exporting medicines to 200+ countries.

**World's Largest Railway Network (Under One Management)**

Indian Railways is one of the largest employers globally, with over 1.2 million employees, and transports over 8 billion passengers annually.

**High Foreign Exchange Reserves**

India's forex reserves stand at $600+ billion, among the highest globally, ensuring economic stability.

**Space Superpower**

India's ISRO (Indian Space Research Organisation) is among the world's top space agencies, launching Chandrayaan-3 successfully in 2023 and planning a human spaceflight mission (Gaganyaan).

# GONE BUT NEVER FORGOTTEN

*Forever in our thoughts, always a part of JUAAM's journey.*

**In Cherished Memory of Sumita Ghosh**

The Mumbai branch of the Jadavpur University Alumni Association lost a cherished member, Sumita Ghosh, on October 10, 2024. She is survived by her husband, Swapan Ghosh, and daughter, Sukanya Ghosh.

An M.A. in English from Jadavpur University (1978) and a B.Ed. graduate from Mumbai University, Sumita taught English literature at K. J. Somaiya Junior College for 21 years. A devoted wife, loving mother, and compassionate soul, she was known for her fearless spirit and commitment to social causes.

A pillar of the Mumbai Alumni Association, she conceptualized and edited **Kaleidoscope**, JUAAM's annual magazine, shaping it into the voice of the alumni for nine years.

Her warmth, resilience, and dedication will forever inspire us.

**In Loving Memory of S.C. De Bakshi**

S.C. De Bakshi left for his heavenly abode on September 28, 2024, at the age of 95 in Chembur, Mumbai. A graduate of the Mechanical Engineering Department from Jadavpur University (then National Council of Education, Bengal) in 1952, he dedicated his career to Rastriya Chemicals & Fertilizers Ltd., where he served as General Manager.

A passionate and active member of JUAAM, he was deeply involved in the cultural and educational initiatives of the Mumbai Alumni Association. His unwavering support and goodwill toward JUAAM and his alma mater will always be remembered.

He is survived by his wife and daughter.

Our heartfelt condolences to his family. May his soul rest in eternal peace

*His wisdom and warmth will forever remain in our hearts*

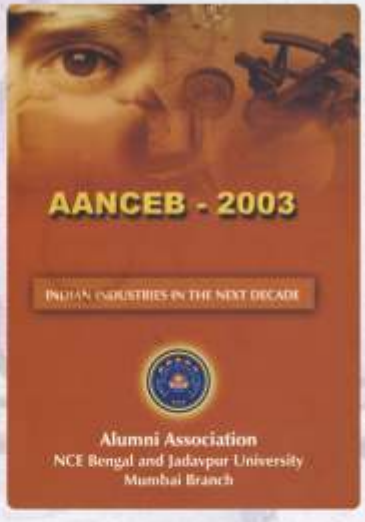
# AANCEB Through the Years : Reliving the Nostalgia

Since its inception, AANCEB has been more than just a magazine—it has served as a mirror to India's journey, capturing the nation's aspirations, challenges, and transformative milestones. Every edition has chronicled India's progress, showcasing the innovation, resilience, and vision that have shaped its destiny.

✨ Dive into Our Archives! ✨

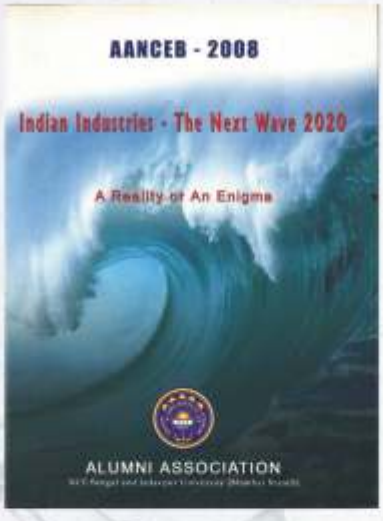
Explore our past issues and revisit the defining moments of India's industrial and technological evolution. To access these editions, visit our Publications Section at https://www.juaam.com/home

Join us in reliving history, embracing the present, and envisioning the future!



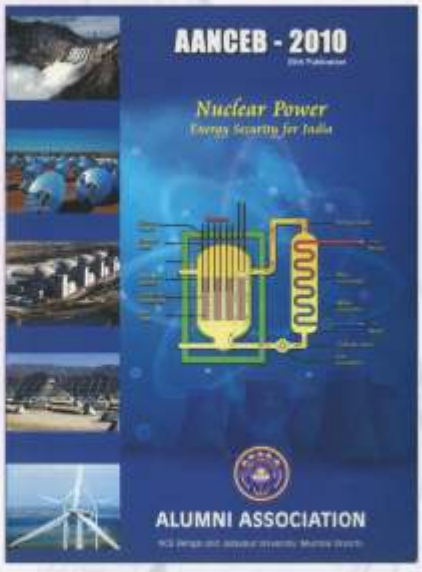

AANCEB – 2003
Indian Industries in the Next Decade

This issue highlights India's strategies for industrial excellence, showcasing success stories, innovations, and transformative growth models.



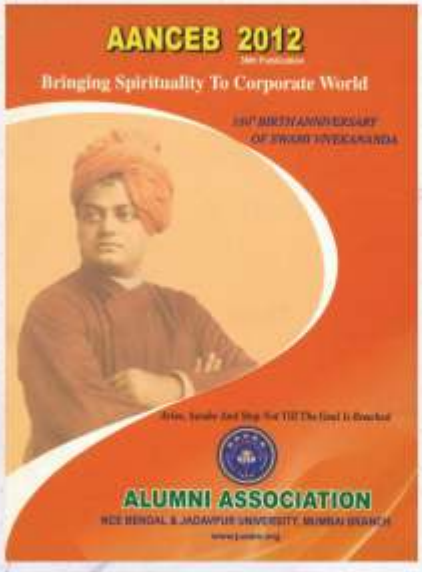

The economic foresight of "Indian Industries The Next Wave (2008)"

In this issue, we explored India's industrial growth—examining its reality versus perception.




Nuclear Power
Energy Security for India - 2010

In this issue, we emphasized the urgency of sustainable energy solutions.




Bringing Spirituality to Corporate World
150th Birth Centenary of Swami Vivekananda - 2012

Marking Swami Vivekananda's 150th birth centenary, this issue explored ethics, leadership, and mindfulness in business.


India as a Global Manufacturing Hub by 2022
Panacea to our aspirations – 2015

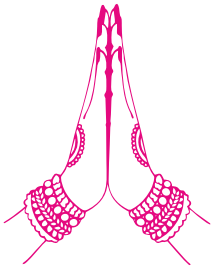
This issue envisioned India as an industrial powerhouse, driving self-reliance and job creation.


India @ 2030 – Sustainable Development Goals & Business Opportunities
Policy, Practice and Path forward – 2017

In this issue, we analyzed policies and strategies for sustainable growth.

AANCEB has been more than a chronicle of history—it has been a catalyst for progress, shaping ideas and inspiring change. As we honour the past, we move forward with the same spirit of innovation, driving India's journey toward excellence

*With best compliments from*



# *Well wishers*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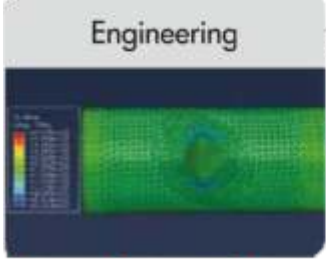





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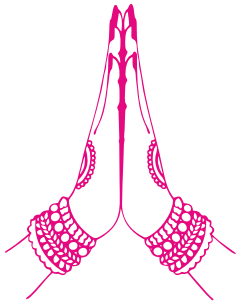

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JNK India Limited is committed to reducing the carbon footprint and improving energy efficiency. JNK is in final stages of completion of India's first CBG based on-site hydrogen generation and dispensing station for refueling H2 run buses for Indian Oil Corporation Limited at Faridabad, Haryana, India. JNK is also focused on other Green projects, including compressed bio-gas (CBG) projects.

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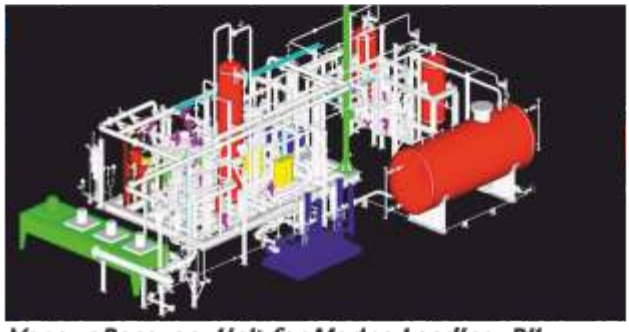

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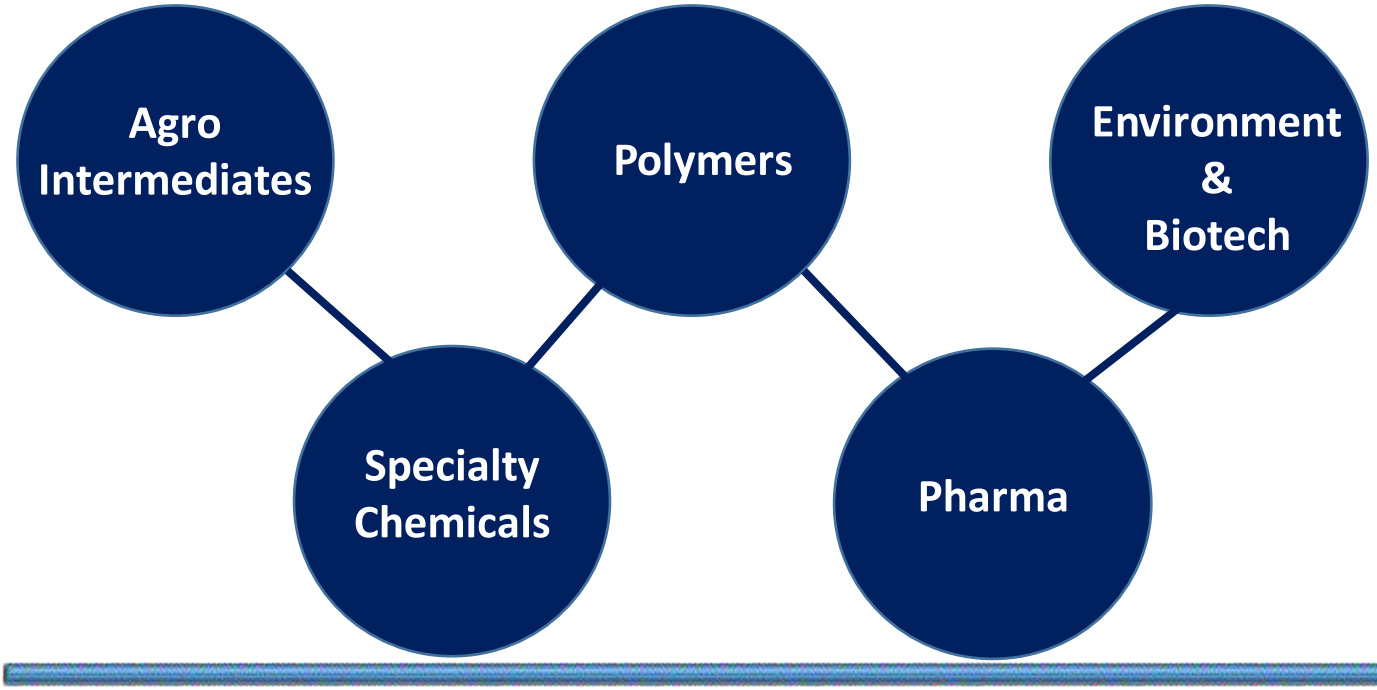


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