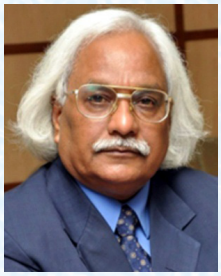
HORIZONS

W-AHEAD Global Impact Quarterly

Empowering Education. Driving Development.

ISSUE NO. 1 | JANUARY, 2026

Message From the President - A Year of Convergence



As we approach the end of 2025, the intersection of higher education and global development has never been more critical. At W-AHEAD, we aren't just observing the future of learning and development, we are architecting it. This year 2025, we've seen record-breaking collaboration across our thrust areas, proving that when we bridge the gap between "Academy" and "Action," we create a nexus of good of eminence from industry, academia and the government to solve real-world problems.

We are conscious that as we navigate in an era of unprecedented global transformation, the role of higher education is being fundamentally redefined and so is the future of work. At the **World Academy of Higher Education and Development (W-AHEAD)**, we believe that the university of the future is not a secluded "ivory tower," but a dynamic engine for social and economic progress.

In 2025, we have witnessed how rapidly emerging technologies, shifting climates, and evolving workplaces are demanding more from our institutions and the pressure of disruption and global competitiveness demanding continuous innovation and creativity in abundance. It is no longer enough for the universities to merely grant degrees; we must cultivate the **agility to innovate, integrity to excel, sustainability to compete and the empathy to lead.**

Our mission at W-AHEAD remains clear: to create a borderless ecosystem where academic excellence, research and innovation meet the industry and corporate and together drive the goals of sustainable development. This year, our focus has been on three strategic pillars:

- **Inclusion:** Expanding our outreach and our academy network to cover areas of high national and global relevance, such as Green Energy Technologies, Productivity in the Age of AI, Youth Skills in the Digital Era, Universities of Tomorrow, our responsibility to maintenance of healthy environment and ecological balance, fostering peace, harmony and development and reaching out to people and community.
- **Integration:** Aligning our Academy advocacy to promote Environmental Stewardship and the UN Sustainable Development Goals (SDGs) to be partners in progress to solve the "wicked problems" of our time.
- **Innovation:** Supporting Inspired Innovative Minds and recognize their monumental contributions and promote Innovation Ecosystem from schools to colleges and universities as also to strive for industry integration and internationalization.

The progress we have made during our foundational years, 2024 and 2025 is a testament to our resolve and collective actions so amply supported by dedication of our Fellows of Eminence and Fellows of the Academy. However, our work is far from over. Rather it has just begun to make our Academy a meaningful forum for fostering innovation and excellence. The distance between "knowing" and "doing" is where W-AHEAD lives, and I invite each of you to join us in shortening that distance.

Thank you, our Fellows of Eminence, the Core Team of W-AHEAD and our sponsors for your formidable support in making your Academy W-AHEAD rise to deliver the promise of Advocacy and Actions with innovation and passion. Thank you for your tireless commitment to excellence and your belief in the transformative power of synergy of minds and the faith in the enriched wisdom of the eminent quarter.

Together, we are not just witnessing the future; we are building it.

With gratitude and purpose.

Prof PB Sharma
President, W-AHEAD

Message From
Executive Chairman W-AHEAD

It gives me immense pleasure to connect with you through W-AHEAD Horizons, our official newsletter that reflects the vision, values, and vibrant activities of the World Academy of Higher Education and Development (W-AHEAD).

In an era marked by rapid technological transformation, global uncertainty, and evolving societal needs, higher education stands at a critical crossroads. Institutions are no longer tasked solely with knowledge dissemination; they are called upon to nurture ethical leadership, foster innovation, and contribute meaningfully to sustainable development. At W-AHEAD, we firmly believe that education must be future-ready, inclusive, and globally connected, while remaining deeply rooted in human values.

Over the past months, W-AHEAD has continued to strengthen its commitment to academic excellence, international collaboration, and capacity building. Through our conferences, faculty development programs, research initiatives, and strategic partnerships, we strive to create platforms that enable educators, researchers, and institutions to share ideas, learn from one another, and collectively address global challenges. Our focus remains on empowering higher education systems to respond proactively to change, rather than reactively adapting to it.

W-AHEAD Horizons is envisioned as a space for dialogue and reflection—a window into our ongoing initiatives, thought leadership, and success stories from across the academic community. I encourage our members and partners to actively engage with this platform by sharing insights, innovations, and best practices that can inspire others and advance our shared mission.

As we move forward, let us reaffirm our collective resolve to shape an education ecosystem that is equitable, resilient, and impactful. Together, through collaboration and commitment, we can contribute to building a better, more enlightened future for learners and societies worldwide.

With warm regards.

Dr. Priyaranjan Trivedi
Executive Chairman
World Academy of Higher Education
and Development (W-AHEAD)

"Given the stakes, the world cannot afford to short-change education. Education is the single-most important investment any country can make in its people and in its future." –

United Nations Secretary - General António Guterres

Eminence of the Academy

Fellows of Eminence of W-AHEAD

The World Academy of Higher Education and Development takes immense pride in conferring the highest honour of Fellow of Eminence upon eminent educationists, eminent scientists and professionals of great integrity whose accomplishments have made a profound impact and brought immense glory to their motherland.

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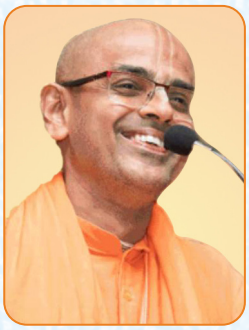
Padma Bhushan
Hon'ble Member, NITI Ayog,
Government of India

Prof. Prem Vrat
Hon'ble Chairman,
BoG, IIT Dhanbad,
Founder Director IIT Roorkee

Dr. Mahesh Verma
Padma Shri
Hon'ble Vice Chancellor,
GGSIPU, New Delhi



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Former Vice Chancellor of
UoH and Jamia Hamdard

Dr. Markandey Rai
Hon'ble Chancellor,
IGTMSU, Arunachal Pradesh

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Secretary General
Association of Indian
Universities

Dr. Saroj Bala
Distinguished Vedic
Research Scientist, Director,
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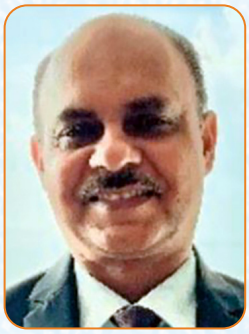
Vice Chairman INAE Delhi Section

Dr. Mangu Singh
IRSCE, Former Managing Director, DMRC, New Delhi

Shri Prabhakar Singh
Former DG CPWD, India



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Former Chief Technologist JSC, NASA, USA

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IRSEE, Former Chairman and First CEO Railway Board, Government of India

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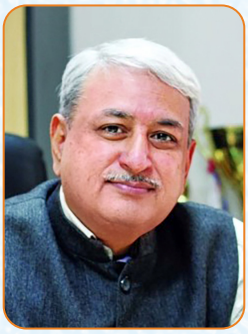

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Jagran University Bhopal &
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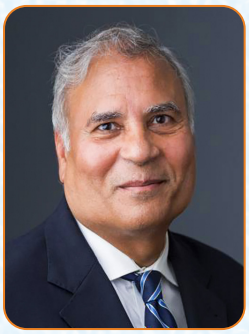

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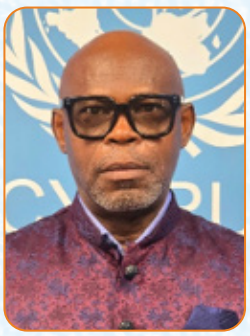
Professor and Graduate
Program Director,
New York Medical College,
USA



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Mr. Anshuman Verma
CEO, Venture Incubator AIVU

Dr. Manish Kumar
Asst Professor NSUT

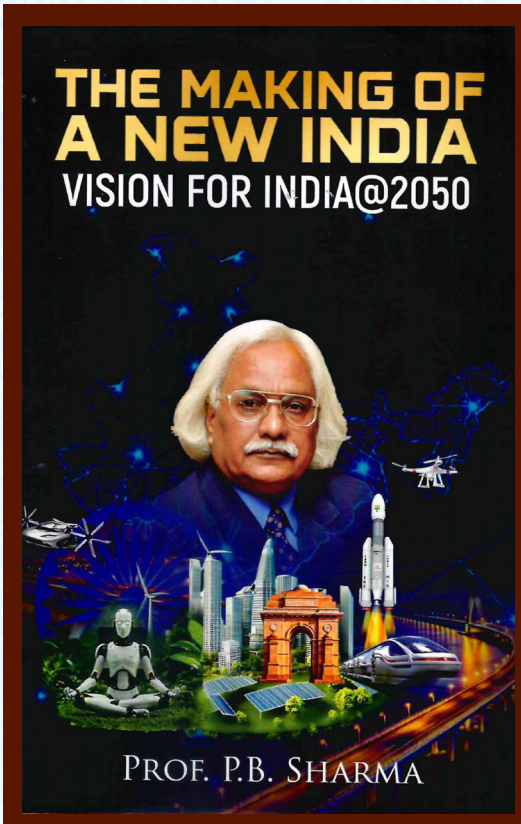
Major W-AHEAD Events during 2025

Recognising the important role of youth in nation building and in accelerating economic growth on the pathways of sustainable development, fostering an era of peace and harmony around the globe, the World Youth Skills Day-2025 was celebrated on July 15th, 2025, at India International Centre by the World Academy of Higher Education and Development, W-AHEAD. Dr VK Saraswat, Member NITI Aayog was the Chief Guest and Prof TG Sitharam, Chairman AICTE was the Distinguished Guest of Honour. Er Pradeep Chaturvedi, Vice President of Indian National Academy of Engineering, IANE, Prof Prem Vrat, Chairman BoG, IIT Dhanbad, VK Yadav, Former Chairman, Railway Board, Dr V Suresh, Former CMD HUDCO and Mr Zafar Sareshwala, Former Chancellor Maulana Azad University were the Eminent Fellows of the Academcy, W-AHEAD present on the occasion. Prof PR Trivedi, Executive Chairman of W-AHEAD and Founder of NIS and IIEE, Dr Markandey Rai, President GPF India, a number of Vice Chancellors and Principals of the Colleges of Delhi University were present at the function besides celebrated young innovators of the new age.

On this momentous occasion, the illustrious scientist and technologist of India, Dr VK Saraswat, was conferred the Lifetime Achievement Award by W-AHEAD for his distinguished service to the nation and monumental contributions to the rise of India to great eminence in science and technology and self-reliance in Defence R&D.

Dr VK Saraswat, member NITI Aayog in his inaugural address congratulated the World Academy, W-AHEAD for organizing such an important day as skilling the youth is of vital importance to our success in achieving the goals of the Viksit Bharat@2047. Dr Saraswat stressed the need for effective linkages between universities and the industries to impart knowledge and skills for the new age learners. The higher education curriculum must be aligned with NEP-2020 with the emphasis on interdisciplinary learning environment and solution research. India is in a highly opportune time as its young population is greatly motivated towards STEM education and Technology Skills.

Prof (Dr) TG Sitharam, Chairman AICTE addressing the august gathering said that the AICTE has developed the model curriculum for engineering and technology programs to foster innovation, interdisciplinary research and skill sets as per the requirements of the industry. Special emphasis has been provided to integrating higher end technology skills of AI, ML, Data Analytics and Computing in all the disciplines of engineering including the core disciplines. Innovation Incubation and industry entrepreneurship has been given a special focus in the curriculum framework inline with NEP-2020.



The book, The Making of a New India: Vision for India@2050 by Prof PB Sharma was released by Dr VK Saraswat, Member NITI Aayog and the dignitaries present on the occasion. A set of books published by IIEE were also released on the occasion.

World Teachers Day-2025 Celebrated by W-Ahead on 5th October 2025

The World Academy of Higher Education and Development (W-AHEAD) successfully celebrated World Teachers' Day-2025 on Sunday, 5th October 2025, in online mode from bringing together eminent educators, leaders, researchers, and policymakers from across India. The celebration centered around this year's global theme — "Empowering Educators: Creating a Bright and Blissful Future for Global Humanity, Building Sustainability"

Message From the Secretary General, W-AHEAD

It is a matter of immense pleasure that W-AHEAD is presenting its first edition of Newsletter, Horizons, the January 2026 Issue. The Newsletter contains Articles from eminent academicians and learned professionals on various topics dealing with higher education and development. The emphasis on ethical and spiritual values for teachers and students, significance of Vidya for humanity, emerging technologies for clean energy transitions, infrastructural and green technologies for sustainable buildings and green structures, role of renewable energy in Indian Railways are the focus areas for the thought provoking articles in this Issue.

The W-AHEAD Newsletter “Horizons” of January 2026 Issue reflects not only the past activities undertaken by W-AHEAD but also presents the future roadmap of the World Academy of Higher Education and Development (W-AHEAD).

I wish the publication of W-AHEAD Newsletter all success.

Prof. (Dr.) H. R. P. Yadav
Secretary General
W-AHEAD

Creating World-Class Universities in India

by ***Dr Priyaranjan Trivedi,*** *Founder Chairman, IIEE, New Delhi*

> ***"Creating world-class universities in India is a long-term and multifaceted endeavor. It requires a supportive policy framework, sustained investment in people and infrastructure, institutional autonomy, and a strong research culture. By aligning global benchmarks with India's unique strengths and societal needs, Indian universities can not only achieve international recognition but also serve as powerful drivers of national development and global progress."***

India's aspiration to emerge as a global knowledge leader is closely tied to the quality of its higher education institutions. With a rich intellectual heritage, a vast youth population, and a rapidly expanding economy, India has strong foundations to develop world-class universities. However, achieving this goal requires deep structural reforms, sustained investment, and a clear understanding of what makes universities globally competitive while remaining socially relevant.

World-class universities are characterized by excellence in teaching, research, and societal engagement. At the core of such institutions is high-quality faculty. India must prioritize attracting, developing, and retaining outstanding academics and researchers. This involves competitive remuneration, transparent recruitment processes, academic freedom, and well-funded research environments. Opportunities for continuous professional development and collaboration with global peers are equally important to keep faculty at the cutting edge of knowledge. Research and innovation are central to global university rankings and reputation. Indian universities have traditionally focused more on teaching than research, and this imbalance must be corrected. Increased public funding for research, encouragement of private and philanthropic investment, and creation of advanced research infrastructure are essential. Universities should promote interdisciplinary research to address complex global challenges such as climate change, healthcare, artificial intelligence, and sustainable development. Strong university–industry linkages can help translate research into practical solutions, foster entrepreneurship, and enhance employability of graduates.

Autonomy and governance reforms are critical enablers of excellence. Globally successful universities enjoy significant academic, administrative, and financial autonomy, allowing them to innovate and adapt swiftly. In India, excessive regulation and rigid control often limit institutional growth. A shift towards outcome-based regulation, coupled with professional and visionary leadership, can empower universities to define their own academic pathways while remaining accountable for performance and quality.

Curriculum design and teaching methods must also evolve to meet global standards. World-class universities emphasize critical thinking, creativity, problem-solving, and experiential learning rather than rote memorization. Indian institutions should adopt flexible, interdisciplinary curricula that allow students to explore multiple fields and develop transferable skills. The use of digital technologies, blended learning models, and open educational resources can enhance access and quality while preparing students for a technology-driven world. Internationalization plays a vital role in building global reputation. Strategic collaborations with leading international universities through joint research, dual-degree programs, faculty exchange, and student mobility can raise academic standards and visibility. At the same time, attracting international students and faculty to Indian campuses will enrich cultural diversity and intellectual exchange. Simplifying visa processes, improving campus

infrastructure, and offering globally competitive programs are important steps in this direction.

Inclusivity and social responsibility must remain central to India's vision of world-class universities. Excellence cannot be pursued at the cost of equity. Institutions should ensure access for talented students from diverse socio-economic backgrounds through scholarships, mentoring, and support systems. Universities must also engage with society by contributing to public policy, community development, and national priorities such as health, sustainability, and inclusive growth. It has been observed that more than 25 Universities and Institutes of National Importance are on the verge of reaching the milestone for becoming a World-Class University but they need expert guidance to give a final finish to their existing systems. W-AHEAD can play a very important role in providing expert guidance to these university level institutions to finally become World-Class Universities. In conclusion, creating world-class universities in India is a long-term and multifaceted endeavor. It requires a supportive policy framework, sustained investment in people and infrastructure, institutional autonomy, and a strong research culture. By aligning global benchmarks with India's unique strengths and societal needs, Indian universities can not only achieve international recognition but also serve as powerful drivers of national development and global progress.

The author Dr. Priyaranjan Trivedi is the President, Confederation of Indian Universities, New Delhi; Founder Chancellor, International University, Nagaland and Indira Gandhi Technological and Medical Sciences University, Arunachal Pradesh; Chairman, Indian Institute of Ecology and Environemnt, New Delhi; President, International Association of Educators for World Peace (Affiliated to United Nations: ECOSOC); President, World Spiritual Parliament, India/USA/Italy/Spain and Executive Chairman, World Academy of Higher Education and Development, New Delhi.

Universities of Tomorrow: Ushering a New Era of Enterprise Development and Integrated Well-being

*by **Prof PB Sharma**, FWAPS, FAeroS, FIE*
President, W-AHEAD

> *"The universities of tomorrow shall not be mere factories for the industrial complex, nor a subservient tool for the interests of a few. They shall stand as a "Sovereign Engine of Translational Discovery", sanctuaries where the pursuit of pure truth is protected, and where radical innovations are filtered through the lens of human ethics. As "Guardians of Global Humanity", we in the university system should commit ourselves to a model of Regenerative Flourishing: where science serves peace, technology fosters harmony, and wealth creation is eternally bound to the noble objectives of sustainability and the integrative wellbeing of people."*

University campuses around the globe are in search of a new architecture for a leaning and research environment that besides fostering critical thinking, unleashes the power of creativity and innovation and offers a systemic support for translation of knowledge and knowhow into new enterprises and wealth creation to make universities in true sense "Global Knowledge Enterprises". Such a learning and research environment would enable the seekers of knowledge to engage both in cultivation of new knowledge as well as its translation for wealth creation, making the object of the universities to be the powerful support system for humanity to march on the path of enlightenment as well as economic prosperity, sustaining quality of life on land and keeping the aspirations of the learned quarters high to touch the altars of human excellence. It is this search for the new campus architecture that is so much needed to make universities march on the pathways of sustainability and excellence, inspiring generations to use knowledge power to drive the agenda of development, peace and harmony.

Reimagining the University of Tomorrow

In the traditional "Ivory Tower" model, universities were isolated sanctuaries of thought, often alienated from the ground realities of the society and were largely disconnected with the urgent mechanics of the global economy. Conversely, the recent shift toward the "Entrepreneurial University", heavily leaning on industry integration and startup culture is also causing concerns for these institutions becoming mere R&D labs and incubators for corporate interests, while driving mad the young, inspired minds to establish their own startups and risk failures in the short term. The great opportunity for the university to continue to be a lighthouse of knowledge and highly enriched wisdom as also to support the march of the humanity on pathways of prosperity, sustainability, and happiness requires a reimagining of the universities of tomorrow as the opportunity is great and cannot be missed else universities shall run the risks of being pushed into insignificance.

The famous management guru of the world, Peter Ducker, is on record to make a prophecy some 25 years ago, at the advent of internet by saying "Thirty years from now the big university campuses will be relics. Universities won't survive. It's as large a change as when we first got the printed book". We hardly have 5 more years for saving the universities from losing their significance and become relics as professed by the learned global guru Peter Ducker. It is in this context also, today, we stand at the precipice of a third way: Universities as the Sovereign Engine of Translational Discovery, Deep Learning, Cultivation of Pathbreaking Research and Game Changing Technology Innovations.

In their new avatars, the Universities of Tomorrow will evolve into "Global Knowledge Enterprises," yet they would do so without sacrificing the very purpose that fosters abundance of creativity makes it valuable, the freedom to pursue breakthroughs that may not have immediate market price but their long term impact on economy and advancement of human society to new horizons of explorations and innovations cannot be undermined. I have seen great gains for the university and its innovative inspired minds coming with such a renewed focus on making universities as global knowledge enterprises, during my days at DCE, DTU and lately at Amity University Gurugram where we could impact and mentor the innovative minds to make a bigger meaning and purpose of the university learning environment, beyond careers and employability. The large number of highly acclaimed new age entrepreneurs and pathbreaking innovators who emerged from these institutions made me feel immensely proud of my association with the institution and the young innovative minds of students and scholars.

Universities to focus on "Wealth Creation with Integrated Well-being"

The goal of the universities of tomorrow cannot remain confined only to serve the interest of the industry and economy. The learned quarters of the university and the inspired minds of students and research scholars need to increasingly acknowledge their role as the change agents for causing a major shift in our focus on the way tomorrow's economies shall flourish. They need to acknowledge that the world tomorrow shall evaluate the nations and their economy not on the size of their GDP but their success in assuring quality of life on land and their compliance with conviction, the cause of sustainability and integrated well-being of the planet and the people. It is here that the universities will not be merely to balance books, but to balance the biosphere. By integrating Environmental Stewardship into the core of enterprise development, universities move beyond the pursuit of profit. Wealth will then be redefined as "Quality of Life on Land," ensuring that every startup born in a university incubator is engineered for sustainability from day one. In this model, the university serves as the moral compass for the industry, setting the standards for green innovation rather than reacting to existing market trends.

Protecting the Seed of Curiosity

For a university to be a torch bearer of enlightenment and knowledge, it must continue to foster curiosity-driven research while keeping its translational focus on new enterprise development. In this context, the universities rather than becoming the research and innovation pipeline for the industries, need to emerge as the "Greenhouse of Curiosity and Vision for the Future." By maintaining their intellectual sovereignty, academic institutions can shield researchers from the "emergent needs" of industry, allowing them to focus on major breakthroughs and development of game changing technology innovations to usher a new era of integrated well-being and prosperity that serves the interest of both the elite as well as those at the bottom of the pyramid. For universities cannot and should not merely become subservient to the interest of a few, being the guardians of the global humanity.

In conclusion, the universities of tomorrow shall not be mere factories for the industrial complex, nor a subservient tool for the interests of a few. They shall stand as a "Sovereign Engine of Translational Discovery", sanctuaries where the pursuit of pure truth is protected, and where radical innovation is filtered through the lens of human ethics. As "Guardians of Global Humanity", we in the university system should commit ourselves to a model of Regenerative Flourishing: where science serves peace, technology fosters harmony, and wealth creation is eternally bound to the noble objectives of sustainability and the enlightenment of all people.

The author Prof PB Sharma is a visionary educationist, renowned thought leader, President of the World Academy of Higher Education and Development, W-AHEAD, Founder Vice Chancellor of DTU, Past President of Association of Indian Universities and currently is Vice Chancellor of Amity University Gurugram.

Spiritual Intelligence for Teachers and Students from Universities, Colleges and other Higher Education Outfits

*by **Dr. Makandey Rai**, Fellow of Eminence, W-AHEAD*

> *"Spiritual intelligence is an essential yet often overlooked dimension of higher education. For teachers and students in universities, colleges, and other higher education outfits, SQ provides the inner compass needed to navigate academic challenges, personal growth, and social responsibility. By embracing spiritual intelligence as a core educational objective, higher education institutions can cultivate not only competent professionals but also compassionate, ethical, and purpose-driven human beings capable of contributing meaningfully to a complex and interconnected world.."*

In an era marked by rapid technological change, intense competition, and growing mental health challenges, higher education institutions are increasingly expected to nurture not only intellectual and emotional capabilities but also deeper human values. Spiritual Intelligence (SQ) offers a vital dimension to holistic education by helping teachers and students find meaning, purpose, and ethical grounding in their academic and personal lives. For universities, colleges, and other higher education outfits, integrating spiritual intelligence can significantly enhance learning environments and societal impact.

Spiritual intelligence refers to the ability to understand oneself at a deeper level, connect with universal values, and apply wisdom, compassion, and integrity in daily life. Unlike religious instruction, SQ is non-sectarian and inclusive. It focuses on self-awareness, inner balance, empathy, ethical decision-making, and a sense of interconnectedness. In higher education, where young adults shape their identities and educators influence future generations, spiritual intelligence plays a crucial role in character formation.

For teachers in higher education, spiritual intelligence enhances professional effectiveness and personal well-being. Academicians today face mounting pressures related to research output, teaching loads, administrative responsibilities, and performance metrics. A spiritually intelligent teacher approaches these challenges with clarity, resilience, and purpose. SQ enables educators to teach with authenticity, patience, and compassion, fostering trust and meaningful engagement with students. It also encourages ethical conduct, humility in scholarship, and a commitment to knowledge as a service to society rather than merely a career achievement.

Teachers with high spiritual intelligence become role models for students. Through their behavior, attitudes, and values, they demonstrate how to balance ambition with integrity and success with social responsibility. Such educators create inclusive classrooms where diverse perspectives are respected, dialogue is encouraged, and learning extends beyond textbooks to life skills and values.

For students, spiritual intelligence is especially important during the formative years of higher education. Students often experience stress, identity confusion, fear of failure, and pressure to succeed in a competitive world. Spiritual intelligence helps them develop inner stability, self-confidence, and clarity of purpose. By nurturing self-reflection and mindfulness, SQ enables students to manage stress, build

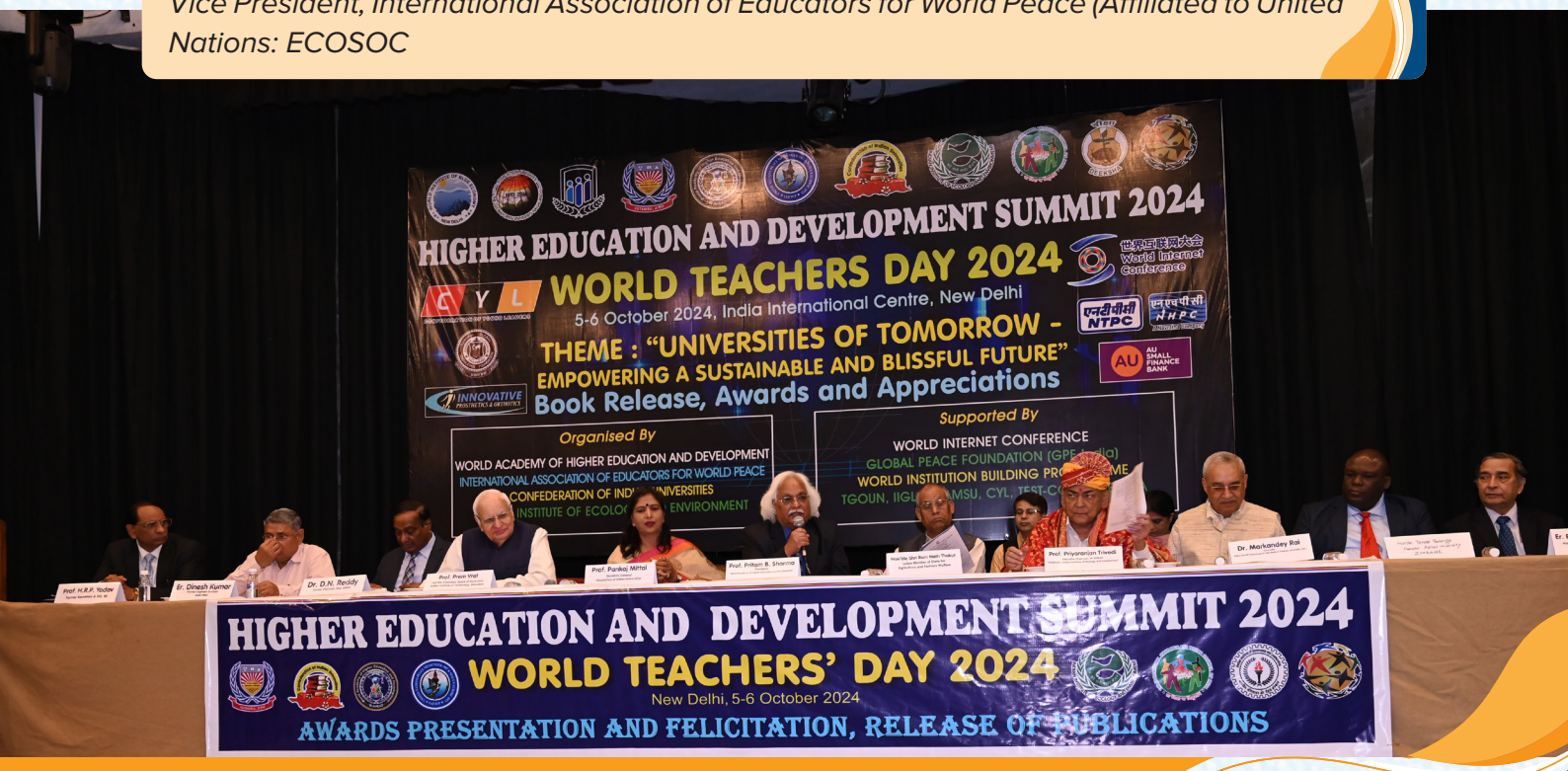
resilience, and maintain emotional balance. Spiritually intelligent students are better equipped to make ethical choices, respect diversity, and cultivate empathy. They learn to view education not merely as a means to employment but as a pathway to personal growth and social contribution. This mindset encourages responsible citizenship, leadership with values, and a lifelong commitment to learning and service.

Higher education institutions can foster spiritual intelligence through intentional policies and practices. Integrating value-based education, ethics, and reflective learning into curricula is a starting point. Courses and workshops on mindfulness, leadership with purpose, emotional and spiritual well-being, and ethics in professional practice can enrich academic programs across disciplines. Creating spaces for dialogue, contemplation, and community service also supports the development of SQ. Co-curricular and extracurricular activities play an equally important role. Yoga, meditation, service-learning projects, mentoring programs, and cultural activities help students and teachers connect with their inner selves and the broader community. Institutional culture should promote respect, inclusivity, compassion, and social responsibility, reinforcing spiritual intelligence through everyday interactions.

Leadership in universities and colleges has a critical role in embedding spiritual intelligence into institutional ethos. When administrators demonstrate ethical leadership, transparency, and concern for well-being, they set a tone that values purpose alongside performance. Policies that support mental health, work–life balance, and community engagement further strengthen spiritually intelligent institutions.

In conclusion, spiritual intelligence is an essential yet often overlooked dimension of higher education. For teachers and students in universities, colleges, and other higher education outfits, SQ provides the inner compass needed to navigate academic challenges, personal growth, and social responsibility. By embracing spiritual intelligence as a core educational objective, higher education institutions can cultivate not only competent professionals but also compassionate, ethical, and purpose-driven human beings capable of contributing meaningfully to a complex and interconnected world.

The author Dr. Markandey Rai, formerly Senior Advisor, UN Habitat is the Chairman, Global Peace Foundation (GPF India), New Delhi and Chancellor, Indira Gandhi Technological and Medical Sciences University, Arunachal Pradesh and National Chancellor and Senior Vice President, International Association of Educators for World Peace (Affiliated to United Nations: ECOSOC



Bioengineering and Biomedical Engineering: Evolution, Current Trends, and Future Prospects

by ***Rakesh Srivastava,[†] and Mahesh Pattabiraman[‡]***
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Bioengineering and biomedical engineering have come a long way from their origins in rudimentary medical devices to cutting-edge AI-driven healthcare solutions. The convergence of engineering, biology, and artificial intelligence is propelling these fields toward an era of unprecedented medical breakthroughs. As AI continues to redefine personalized medicine, robotics, and neuroengineering, the future holds limitless possibilities for improving human health and longevity. Educators, researchers, and policymakers must collaborate to ensure that these innovations remain ethical, accessible, and beneficial for all of humanity.

A. Introduction

Bioengineering and biomedical engineering are rapidly evolving disciplines that facilitate the application of fundamental knowledge in life sciences and engineering principles to develop innovative biological and medical solutions. These fields have revolutionized healthcare by integrating technology, biology, and engineering to address complex medical challenges, leading to groundbreaking advancements such as prosthetic limbs, artificial organs, advanced imaging technologies, and neural interfaces. The scope of bioengineering extends far beyond medicine, influencing a wide range of industries, including environmental sustainability, agriculture, and industrial biotechnology. In environmental engineering, bioengineering plays a critical role in wastewater treatment, carbon capture, and bioremediation, where engineered microorganisms help degrade pollutants and mitigate environmental damage. In agriculture, bioengineered crops with enhanced resistance to disease, drought, and pests are improving global food security while reducing reliance on chemical fertilizers and pesticides. Additionally, synthetic biology and bioprocess engineering have enabled the production of biofuels, biodegradable plastics, and bio-based chemicals, contributing to sustainable industrial practices and reducing dependence on fossil fuels.

As these disciplines continue to evolve, AI is emerging as a transformative force, driving advancements in biomedical diagnostics, personalized medicine, smart prosthetics, and bioinformatics while also optimizing biomanufacturing and environmental monitoring. This write-up explores the historical development of bioengineering and biomedical engineering, their current state, and future prospects, particularly focusing on how AI is shaping the trajectory.

B. A Brief History of Bioengineering and Biomedical Engineering

The initial practice of bioengineering can be traced back to its modest origins in ancient civilizations, where rudimentary prosthetics, surgical instruments, and early methods of water purification and fermentation demonstrated the intersection of biology and engineering. A formal approach to addressing biological and medical application leveraging scientific knowledge emerged in the early 20th century driven by rapid advancements in healthcare, agriculture, and environmental science, which would be later recognized as the origins of these modern fields of engineering. The formalization of biomedical engineering began with groundbreaking developments in medical imaging and diagnostic tools. The invention of the electrocardiogram in 1903 and the discovery of X-ray technology revolutionized medical diagnostics, enabling non-invasive assessment of internal organs. By the mid-20th century progress in biomedical engineering led to life-saving innovations such as dialysis machines, pacemakers, and artificial heart valves, significantly improving patient survival and quality of life. As the field evolved, bioengineering expanded beyond

medical devices to include tissue engineering, biomaterials, and biomechanics. The 1970s and 1980s saw the development of MRI and CT scan technologies, further cementing biomedical engineering's role in modern healthcare. Simultaneously, bioengineering made strides in other domains, such as genetic engineering in agriculture led to the production of high-yield, pest-resistant crops, while environmental bioengineering introduced microbial solutions for wastewater treatment and pollution control.

The completion of the Human Genome Project in 2003 was a pivotal moment that accelerated the convergence of bioengineering with computational biology, genetics, and synthetic biology. This milestone paved the way for gene editing technologies like CRISPR, precision medicine, and bioinformatics-driven and -guided drug discovery. In recent decades, bioengineering has further expanded into areas such as renewable biofuels, biomanufacturing, and AI-driven biological systems, shaping a future where engineering solutions optimize not only healthcare but also environmental sustainability and global resource management.

C. The Current State of Bioengineering and Biomedical Engineering

Bioengineering and biomedical engineering have evolved into dynamic, multidisciplinary fields that integrate principles from mechanical, electrical, chemical, and computational engineering with biological sciences. This convergence has led to significant advancements across various sectors, underscoring the fields' economic impact, job growth, and transformative innovations. As per the US Bureau of Labor Statistics, the bioengineering and biomedical engineering sectors have experienced substantial growth in the last decade, reflecting their critical role in modern economies. As of May 2023, the United States employed approximately 19,320 bioengineers and biomedical engineers, with an average annual wage of $106,700. In the United States, the employment of bioengineers and biomedical engineers is projected to grow 7% from 2023 to 2033, a rate faster than the average for many other occupations, making it one of the fastest growing fields. This growth is expected to result in approximately 3,000 new job openings annually over the next decade, driven by the ongoing need to recruit newer talent for the medical technologies to support the medical industry's mission of increasing life expectancy and quality of life. The demographic composition of this workforce indicates that 25% are women, while 75% are men, highlighting ongoing efforts to promote diversity within the field. The influence of bioengineering and biomedical engineering extends across multiple domains, leading to groundbreaking innovations that have transformed healthcare and related industries:

D. Areas of impact for B/BM Engineering

The core competencies of biological and biomedical engineers impact key areas of society and economy. Some of the prominent areas of influence for biomedical engineering is discussed below:

i. **Artificial Organs and Prosthetics** Biomedical engineering has profoundly transformed medicine through the development of artificial organs and prosthetics, effectively addressing challenges such as organ failure and limb loss. Historically, while significant strides were made in combating terminal and infectious diseases, solutions for organ failure and limb loss remained limited. However, breakthroughs in tissue engineering and the creation of artificial organs and prosthetic devices have dramatically changed this landscape. For instance, the BiVACOR artificial heart, developed by Australian biomedical engineer Daniel Timms, has successfully supported patients with end-stage heart failure, offering a potential long-term solution and reducing reliance on donor transplants. Notable example such as the BiVACOR Total Artificial Heart, developed by Australian biomedical engineer Dr. Daniel Timms; this device utilizes a magnetically levitated, spinning disc to replicate natural blood flow, reducing the need for donor heart transplants. In a groundbreaking case, an Australian patient with end-stage heart failure lived with the BiVACOR heart for over 100 days before receiving a donor transplant, marking a significant milestone in medical technology; highlights the profound role of BM engineering in enhancing quality of life and economic value. In the United States, the SynCardia Total Artificial Heart has been a pivotal development. Approved by the FDA in 2004, it serves as a bridge

to transplant for patients with biventricular heart failure. The device has been implanted in over 1,250 patients, demonstrating its critical role in sustaining patients awaiting donor hearts.

ii. **Bionics and Neural Interfaces** Innovations such as neurally controlled prosthetic limbs have emerged, allowing users to control artificial limbs through brain signals. This integration of neurology and engineering exemplifies the cutting-edge developments in biomedical engineering, significantly enhancing the quality of life for individuals with limb loss.

iii. **Implantable Pulse Generators** (IPG) play increasingly pivotal role in modern medical treatments, delivering electrical impulses to specific body regions to manage various conditions. In neuromodulation, IPGs are integral to devices such as stimulators of the spinal cord, vagus nerve, and deep brain, to alleviate chronic pain by disrupting pain signal transmission to the brain. Progress in B/BM engineering have led to the design and development of devices that optimize energy use based on biomechanical study of wearer's activities and nerve impulses, which reduces energy usage and increases pain relief. These advancements have resulted in devices that requires no recharge up to 10 years, and are better at producing the intended medical effect at lower cost. In cardiology, IPGs function as pacemakers, regulating heart rhythms in patients with arrhythmias. These devices monitor cardiac activity and provide electrical stimulation to maintain appropriate heart rates, significantly improving patients' quality of life. The evolution of IPGs underscores the synergy between biomedical engineering and clinical practice, leading to innovative solutions for complex health challenges.

iv. **Tissue engineering and regenerative medicine** focuses on restoring or replacing damaged tissues and organs. A notable advancement in this field is the development of 3D bioprinting technologies, which enable the fabrication of complex tissues and organ prototypes by precisely depositing layers of living cells and biomaterials. This approach holds promise for creating functional tissues for transplantation and disease modeling. Additionally, stem cell-based therapies have been explored for their potential to regenerate damaged tissues, offering hope for conditions such as spinal cord injuries and heart diseases. Bioengineered skin grafts have also been developed to treat burn victims, providing improved healing and reduced scarring compared to traditional methods.

v. **Biomedical Imaging and Diagnostics** Advances in biomedical imaging and diagnostics have revolutionized disease detection and monitoring. The integration of artificial intelligence (AI) with imaging modalities like MRI, CT, and PET scans has enhanced early disease detection by improving image analysis accuracy and speed. Wearable biosensors have emerged as tools for real-time health monitoring, enabling continuous tracking of vital signs and early identification of health anomalies. Furthermore, optical imaging techniques have been developed for non-invasive diagnostics, allowing clinicians to observe tissues at the cellular level without the need for surgical intervention

vi. **Neuroengineering and Brain-Machine Interfaces** Neuroengineering combines neuroscience and engineering to develop technologies that interface with the nervous system. Implantable neurostimulators have been designed to manage neurological disorders such as Parkinson's disease and epilepsy by delivering electrical stimulation to specific brain regions. Brain-computer interfaces have enabled communication for patients with paralysis, allowing them to control external devices using neural signals. AI-driven neuroprosthetics have further advanced this field by restoring motor functions, offering more natural and intuitive control of prosthetic limbs.

vii. **Synthetic Biology and Genetic Engineering** Synthetic biology and genetic engineering involve designing and constructing new biological parts and systems. CRISPR-based gene editing has emerged as a powerful tool for correcting genetic disorders by enabling precise modifications to DNA sequences. Engineering microorganisms for therapeutic drug production has led to more efficient and cost-effective manufacturing processes for medications. Personalized medicine approaches, informed by genetic

profiling, have been developed to tailor treatments to individual patients, enhancing efficacy and reducing adverse effects.

viii. **Smart Medical Devices and Robotics** The integration of AI and robotics into medical devices has led to the development of smart systems that enhance surgical precision and patient care. AI-powered robotic surgery systems assist surgeons in performing complex procedures with greater accuracy and minimal invasiveness. Soft robotics have been utilized in prosthetic limbs to provide sensory feedback, improving the user's ability to interact with their environment. Autonomous healthcare robots have also been introduced to assist in elderly care and rehabilitation, offering support in daily activities and monitoring health conditions.

E. Future Prospects and the Role of AI in Bioengineering

The future of bioengineering and biomedical engineering is set to be profoundly influenced by advancements in artificial intelligence (AI), quantum computing, and materials science. AI is emerging as a transformative force, enabling inanimate systems to perform human-like decision-making processes, thereby revolutionizing diagnostics, personalized medicine, and the development of intelligent biomedical devices. The integration of quantum computing is poised to enhance computational capabilities, allowing engineers to tackle complex problems more efficiently, such as simulating molecular interactions for drug discovery and optimizing large-scale biological data analyses. Simultaneously, breakthroughs in materials science are paving the way for the creation of biomimetic materials that replicate or even surpass the functions of natural organs, leading to innovative solutions in tissue engineering and regenerative medicine. Collectively, these technological advancements are expected to drive significant progress in the fields of bioengineering and biomedical engineering, offering unprecedented opportunities for innovation and improved healthcare outcomes.

AI-Driven Precision Medicine Machine learning algorithms can analyze vast datasets from genomics, proteomics, and metabolomics to develop personalized treatment plans. AI-powered drug discovery platforms are expediting the identification of novel therapeutics, reducing development costs and timelines. Additionally, predictive analytics is enabling early diagnosis and intervention for chronic diseases. **AI in Medical Imaging and Diagnostics** AI-enhanced imaging tools are improving the accuracy and efficiency of disease detection. Deep learning models can identify tumors, fractures, and neurological abnormalities with higher precision than traditional radiologists. AI-assisted image reconstruction is also reducing noise and improving resolution in MRI and CT scans. **AI-Enhanced Robotics and Prosthetics** The integration of AI with robotic-assisted surgery is enhancing precision, minimizing invasiveness, and reducing recovery times. AI-driven exoskeletons and bionic limbs are restoring mobility to individuals with spinal cord injuries and amputations. Smart prosthetics with AI-driven adaptive controls are allowing more natural movements and feedback. **Bioinformatics and AI in Drug Development** AI is streamlining drug development through computational modeling, virtual screening, and simulation of biochemical interactions. AI-driven models are predicting drug-target interactions with greater accuracy, accelerating clinical trials, and optimizing drug formulations for maximum efficacy and minimal side effects. **AI in Neuroengineering and Brain-Computer Interfaces** AI-powered BCIs are enabling seamless communication between the human brain and external devices. These interfaces are not only aiding individuals with disabilities but are also paving the way for cognitive enhancement and direct neural augmentation. AI-driven neuroprosthetics are improving control over artificial limbs through real-time adaptive learning.

F. Areas of Potential Employment for B/BM Engineers:

Biomedical engineers have the opportunity to work across a diverse array of sectors, each offering unique applications of their expertise: **Research and Development (R&D):** In R&D settings, biomedical engineers engage in designing and testing medical devices, developing new therapies, and innovating healthcare technologies. They often collaborate with scientists and medical professionals to bring cutting-edge solutions from concept to clinical application. **Medical**

Equipment Manufacturing: Professionals in this sector focus on creating and improving medical instruments and devices, such as imaging machines, prosthetics, and diagnostic tools. Their work ensures that medical equipment is safe, effective, and meets regulatory standards. **Clinical Engineering:** Within healthcare facilities, clinical engineers manage medical equipment, ensuring its optimal performance and safety. They are responsible for the selection, maintenance, and integration of technology in clinical settings to enhance patient care. **Biomechanics:** This specialization involves analyzing the mechanical aspects of biological systems. Biomedical engineers in biomechanics develop prosthetic limbs, orthopedic implants, and assistive devices that mimic natural movement, improving mobility and quality of life for patients. **Biomedical Imaging:** Experts in this field develop and refine imaging technologies like MRI, CT scans, and ultrasound. Their work enhances the ability to diagnose and monitor diseases through non-invasive visualization of the body's internal structures. **Regulatory Affairs:** Biomedical engineers in regulatory roles ensure that medical products comply with governmental regulations and standards. They prepare documentation for approvals and work closely with regulatory bodies to navigate the complex landscape of medical device and pharmaceutical approvals. **Academic and Teaching:** Some biomedical engineers pursue careers in academia, teaching the next generation of engineers and conducting research to advance the field. They contribute to educational programs and publish findings that drive innovation.

Consulting: In consulting roles, biomedical engineers provide expertise to healthcare organizations, helping to optimize the use of technology, improve processes, and implement new systems effectively.

G. Role of Educators in Preparing Future Engineers

Educational institutions play a pivotal role in shaping the next generation of bioengineers and biomedical engineers for the betterment of society, ensuring they are equipped to meet current needs and future challenges. To prepare students effectively, educators should integrate transdisciplinary teaching strategies that encompass not only engineering principles but also insights from biology, computer science, and ethics. Implementing challenge-based learning approaches can expose students to real-world problems, fostering critical thinking and problem-solving skills essential for innovative solutions. Moreover, providing experiential learning opportunities, such as course-based undergraduate research experiences, allows students to engage in authentic scientific inquiry, enhancing their practical skills and readiness for industry demands. Educational policy decisions must thoughtfully consider the integration of AI, the ethics of engineering research and its applications, and other emerging factors to effectively prepare students for future challenges. Incorporating AI into educational strategies offers opportunities to enhance learning experiences and operational efficiencies; however, it also raises ethical concerns such as bias, privacy, and the potential for misuse. To address these issues, it is essential to establish robust ethical guidelines and transparent policies that govern AI's use in educational settings. Additionally, fostering interdisciplinary collaboration among educators, technologists, and ethicists can lead to the development of curricula that not only impart technical skills but also emphasize ethical considerations, critical thinking, and social responsibility. By proactively addressing these aspects, educational institutions can ensure that graduates are not only proficient in advanced technologies but also equipped to apply them conscientiously in their professional endeavors. By adopting these educational methodologies, educators can cultivate professionals capable of navigating and addressing the complexities of future biomedical challenges.

H. Conclusion

Bioengineering and biomedical engineering have come a long way from their origins in rudimentary medical devices to cutting-edge AI-driven healthcare solutions. The convergence of engineering, biology, and artificial intelligence is propelling these fields toward an era of unprecedented medical breakthroughs. As AI continues to redefine personalized medicine, robotics, and neuroengineering, the future holds limitless possibilities for improving human health and longevity. Educators, researchers, and policymakers must collaborate to ensure that these innovations remain ethical, accessible, and beneficial for all of humanity.

Green Tracks to Sustainable Development: The Transformative Role of Renewable Energy in Indian Railways

*by **Er. Vinod Kumar Yadav**, Fellow of Eminence W-AHEAD*
Former Chairman & CEO, Railway Board

> ***The integration of renewable energy into Indian Railways represents one of the most impactful infrastructure transformations of our time. It demonstrates that large-scale systems can pivot toward sustainability while delivering economic, social, and environmental dividends.***
>
> ***By building clean-energy capabilities, training a skilled workforce, reducing costs, and lowering emissions, this journey is empowering people and driving holistic development across the nation. As we move toward the final steps of electrification and deeper renewable penetration, Indian Railways is not just modernizing transport — it is helping build the foundation for a greener, more prosperous, and more inclusive India.***

Indian Railways stands as the lifeline of India — a vast network that moves over 8 billion passengers and more than 1.2 billion tonnes of freight every year. It connects remote villages to bustling cities, supports industries, enables trade, and powers economic growth across the length and breadth of the country. Yet, this very scale once made it one of the largest consumers of diesel in the nation, contributing significantly to operational costs and carbon emissions.

Over the past decade, a quiet but profound transformation has taken place. Through accelerated electrification and large-scale adoption of renewable energy, Indian Railways has emerged as a global model of sustainable infrastructure development. This journey is not merely about replacing one form of energy with another; it is about empowering people through new skills and opportunities, reducing environmental burden, achieving energy security, and driving inclusive national development.

The Accelerated Journey Toward Full Electrification

The foundation of this green transition is near-complete electrification of the broad-gauge network. From just 40% electrification in earlier years, the pace accelerated dramatically after 2014. Daily electrification rates jumped from an average of 1.42 km (2004–2014) to over 15 km per day in the 2019–2025 period. By November 2025, approximately 99.2% of the broad-gauge network — covering over 69,400 route kilometers — had been electrified, making Indian Railways one of the most extensively electrified rail systems in the world.

This achievement has dramatically reduced dependence on diesel, lowered fuel costs, improved operational reliability, and enabled faster, more efficient train services, including the expansion of high-speed and semi-high-speed trains like Vande Bharat.

Electrification alone, however, is only part of the story. True sustainability requires clean, renewable sources to power those electric trains.

Renewable Energy Integration: A Remarkable Scale-Up

Indian Railways has pursued an ambitious strategy to meet a growing portion of its traction (train-running) power needs from renewable sources. Solar energy has led this effort.

- From a modest 3.68 MW in 2014, solar capacity commissioned across the railway network reached 898 MW by November 2025 — a nearly 244-fold increase.
- Of this, around 629 MW (approximately 70%) directly supports electric train traction, while the balance powers stations, workshops, offices, and residential quarters.
- Solar installations now cover 2,626 railway stations nationwide, bringing clean energy to diverse geographies — from remote rural outposts to major urban junctions.

Wind power has complemented solar efforts, with 93 MW of wind capacity commissioned for traction use. Additionally, Indian Railways has secured 1,600 MW of round-the-clock (RTC) hybrid renewable power through power purchase agreements, ensuring more stable and reliable clean energy supply.

These initiatives directly contribute to the long-term vision: Net Zero Carbon Emissions by 2030. By progressively meeting traction power demand through renewables, combined with energy efficiency measures, Indian Railways is positioning itself as a leader in decarbonizing large-scale transport infrastructure.

Driving Development Through Clean Energy

The benefits of this transition extend far beyond environmental gains.

Economic Impact Every megawatt of renewable power installed reduces electricity procurement costs over the long term and shields operations from volatile fossil fuel prices. Savings are reinvested into passenger amenities, safety upgrades, station redevelopment, and expansion of services to underserved regions. Lower freight costs also make Indian industries more competitive in domestic and global markets.

Empowerment Through Skills and Employment The rapid deployment of solar plants, wind turbines, hybrid systems, and energy storage has created demand for new technical skills. Railway personnel have received specialized training in installation, operation, and maintenance of renewable systems. This upskilling empowers thousands of employees, enhancing their career prospects and contributing to national human capital development.

Beyond the organization, the supply chain for solar panels, inverters, mounting structures, and monitoring systems has stimulated manufacturing, logistics, and service sectors — generating direct and indirect jobs, particularly in renewable energy hubs across states.

Social and Environmental Gains Cleaner railway operations mean reduced air pollution in cities and along rail corridors, improving public health. Reliable, affordable transport powered increasingly by renewables supports equitable access to education, healthcare, and economic opportunities in remote areas. By demonstrating large-scale renewable integration, Indian Railways inspires other sectors — steel, cement, mining, and heavy industries — to accelerate their own transitions.

In essence, renewable energy in railways is not just a technical upgrade; it is a powerful instrument of empowerment and inclusive development.

Challenges and the Path Forward

Despite impressive progress, challenges remain. Renewable energy is intermittent by nature, requiring sophisticated grid integration, energy storage solutions, and balancing mechanisms. Land availability for large solar parks, initial capital requirements, and coordination with state utilities have also posed hurdles.

Indian Railways has responded proactively:

- Investing in RTC hybrid renewable tenders with storage components
- Exploring innovative deployment models (rooftop, land-based, between-tracks)
- Partnering with developers through open-access arrangements
- Pursuing diversification — solar + wind + potential future options like green hydrogen pilots

Looking ahead to 2030 and beyond, the goal is clear: scale renewable capacity further, achieve full alignment with net-zero objectives, and continue innovating to make clean energy the default choice for one of the world's largest railway systems.

Conclusion

The integration of renewable energy into Indian Railways represents one of the most impactful infrastructure transformations of our time. It demonstrates that large-scale systems can pivot toward sustainability while delivering economic, social, and environmental dividends.

By building clean-energy capabilities, training a skilled workforce, reducing costs, and lowering emissions, this journey is empowering people and driving holistic development across the nation. As we move toward the final steps of electrification and deeper renewable penetration, Indian Railways is not just modernizing transport — it is helping build the foundation for a greener, more prosperous, and more inclusive India.

I am confident that this momentum will continue, setting an example for public enterprises worldwide and contributing meaningfully to India's climate commitments and sustainable development goals.

Transforming Our World: Opportunities, Innovations, and Challenges Facing Higher Education in the Digital Age

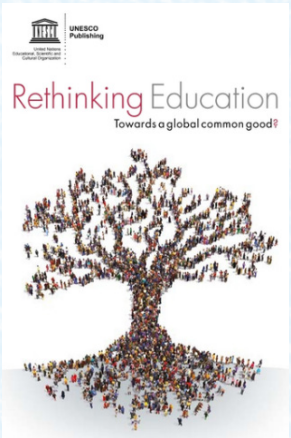
*by **Dr. Anoop Swarup**, Fellow of Eminence W-AHEAD*
Secretary General, Association of Universities of Asia Pacific

> ***By fostering collaboration, promoting equity and inclusion, and leveraging innovative pedagogical approaches, higher education institutions can continue to play a central role in shaping a sustainable and inclusive future. As the world continues to grapple with complex socio-political challenges, the role of higher education in driving transformative change for a better world through innovation, invention and peace will remain indispensable.***

Synopsis

Universities and Higher education institutions (HEIs) serve as pivotal agents of societal transformation, driving progress through education, research, and community engagement. By integrating sustainability into curricula and fostering partnerships, HEIs contribute to global development and address complex challenges. The adoption of advanced technologies—such as artificial intelligence, virtual reality, and digital learning platforms—has enhanced educational practices, promoted collaboration, and supported flexible, personalized learning environments. Universities play a critical role in advancing the Sustainable Development Goals (SDGs) by acting as hubs for innovation, interdisciplinary research, and technology transfer. Their efforts span climate resilience, clean energy, and urban sustainability, often in collaboration with governments, industries, and communities.

Global Common Good



Higher education institutions (HEIs) are not only centres of knowledge production but also catalysts for societal transformation. They play a multifaceted role in fostering change through education, research, and community engagement through emergence of technological innovations and Artificial Intelligence. As highlighted in several studies, HEIs contribute to sustainable development by integrating sustainability into curricula, promoting stakeholder partnerships, and ensuring long-term institutional support. As HEIs and universities increasingly adopt holistic approaches for change, there is a strong case for more investment and funding both public and private for integration and evolution of a better future world order. Technology innovations in higher education are significantly transforming the approach to societal challenges by enhancing educational practices, fostering collaboration, and promoting sustainability. These advancements enable institutions to rethink education for global common good and adapt to the evolving needs of society, thereby positioning themselves as catalysts for change.

https://unesdoc.unesco.org/ark:/48223/pf0000232555

Technology and Enhanced Learning Experiences for an entrepreneurial mindset

- The integration of AI, VR, and AR technologies has revolutionized teaching methodologies, making learning more engaging and immersive (López et al., 2024).
- These technologies facilitate international collaboration, allowing students to work on global challenges in real-time, thus broadening their perspectives and problem-solving skills (López et al., 2024).

- The integration of advanced technologies in higher education has significantly transformed the learning experience, particularly through the adoption of digital tools and platforms. This transformation has been accelerated by the COVID-19 pandemic, leading to a more flexible, personalized, and interactive educational environment. Key advancements include:

Digital Learning Platforms

Online Courses and Webinars: These have made education more accessible, allowing students to learn at their own pace and convenience.

Blended Learning Models: Combining traditional and digital methods enhances student engagement and accommodates diverse learning styles.

Interactive Technologies

Artificial Intelligence (AI): AI-driven tools provide personalized learning experiences and real-time feedback, fostering a more engaging learning environment.

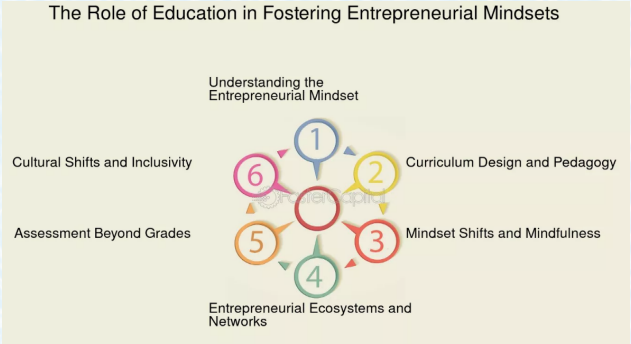
Virtual and Augmented Reality (VR/AR): These technologies create immersive learning experiences, allowing students to interact with content in innovative ways.

Learning Management Systems (LMS)

Gamification and Collaborative Tools: These features in LMS promote active learning and knowledge construction, aligning with constructivist principles.

Sustainability and Societal Engagement

- Higher Education Institutions (HEIs) are increasingly focusing on sustainability, integrating it into curricula and research to address global challenges (Shih et al., 2025).



Source: *https://fastercapital.com/topics/the-role-of-education-in-fostering-entrepreneurial-mindset-in-a-mixed-economy.html*

Universities as Hubs for SDG Innovation and Networking for a Sustainable Future

Universities are more than institutions of higher learning; they are incubators of ideas, technologies, and leaders who can shape a sustainable future. Their multidimensional influence spans education, research, community engagement, and policymaking. By aligning their efforts with the SDGs, universities can play a transformative role in achieving global sustainability. As climate crises intensify, social inequalities persist, and resource scarcity looms, the importance of universities in fostering innovative solutions and holistic approaches cannot be overstated.

The Role of Universities in Innovation

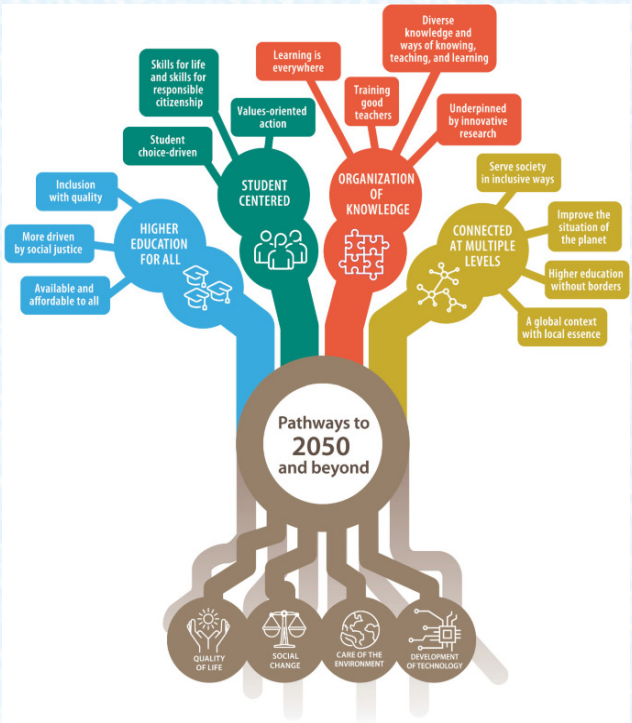
1. **Research and Development:** Universities are at the forefront of solving global challenges by investing in cutting-edge research. For example:
   - Developing climate-resilient crops to address food security.
   - Innovating in clean energy sources such as hydrogen fuel and advanced solar technologies.
   - Exploring data-driven solutions for urban sustainability, such as smart city initiatives.
2. **Interdisciplinary Approach:** Universities encourage cross-disciplinary synergies by integrating STEM (science, technology, engineering, and mathematics) fields with humanities and social sciences. For instance:
   - Environmental science programs collaborate with law faculties to devise policies for environmental governance.
   - Business schools team up with engineering departments to create sustainable supply chain models. This interdisciplinary ethos ensures that complex SDG challenges are addressed from multiple perspectives.
3. **Technology Transfer:** Universities act as bridges between academic research and industry application. By establishing technology transfer offices (TTOs) and innovation hubs, they ensure that laboratory

discoveries evolve into commercially viable, real-world solutions. For example:

- Patents developed for affordable water filtration systems have significantly improved access to clean water in underdeveloped regions.

Future Universities as Networking Hubs

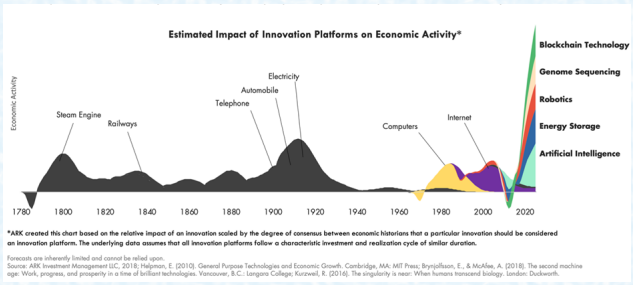
UNESCO IESALC's public consultation on the futures of higher education has resulted in the development of a holistic framework envisioning pathway to 2050 and beyond. Drawing from the collective hopes and concerns about the future, particularly in the context of higher education, four interconnected pathways have been identified. Together, these pathways offer a comprehensive vision for shaping a better and more sustainable future



Source: *https://link.springer.com/chapter/10.1007/978-3-658-42948-5_9*

The future of Innovation in Universities and HEIs through Artificial Intelligence (AI)

An exciting and dynamic frontier, for the Universities and the HEIs will shape how humanity engages with technology, society, and global challenges. An exploration of the future potential and implications of AI across various sectors.



Source: *https://www.nikkoam.co.nz/sp/ark/five-innovation-platforms-investors-shouldnt-miss-in-2019*

1. AI in Future Technologies

- **Autonomous Systems:** AI will continue driving advancements in autonomous vehicles, drones, and robotics. Self-driving cars, for instance, will likely become a norm, reducing traffic accidents and optimizing urban transportation systems.
- **Generative AI:** The rise of models capable of generating text, images, music, and even video content will revolutionize creative industries, education, and communication.
- **Quantum AI:** Integration with quantum computing will exponentially increase AI's processing capabilities, enabling solutions to previously unsolvable problems in fields like drug discovery, climate modelling, and cryptography.

2. AI in Healthcare

- **Personalized Medicine:** AI will enable the design of individualized treatment plans based on a patient's genetic profile, lifestyle, and health history, making healthcare more precise and effective.
- **Predictive Healthcare:** AI-driven analytics will play a vital role in predicting disease outbreaks, tracking pandemics, and identifying at-risk populations before issues escalate.
- **Enhanced Diagnostics:** Future AI systems will refine their ability to analyse medical imaging, such as MRIs or CT scans, improving early detection of diseases and reducing diagnostic errors.

3. AI in Climate and Environmental Action

- Climate Adaptation
- Sustainability Optimization
- Biodiversity Monitoring

4. **AI in Work and Society**
   - Workforce Transformation
   - Global Collaboration
   - Social Good
5. **Ethical and Regulatory Challenges**
   - Ethical AI Development
   - Global Regulations
   - AI Safety
6. **AI in Space Exploration**
   - Autonomous Exploration.
   - Terraforming and Resource Utilization.
   - AI and Human-AI Collaboration
   - Augmented Intelligence
   - Human-Centered AI
7. **Emerging Innovations and Theoretical Advances**
   - Artificial General Intelligence (AGI): Progress in AGI—where machines achieve human-like cognitive abilities—will redefine relationships between humans and technology, prompting ethical discussions and societal adaptation.
   - Neuro-Symbolic AI: Combining neural networks with symbolic reasoning could lead to AI systems that are both intuitive and explainable, addressing current limitations in interpretability.
   - AI and the Brain: Research into brain-computer interfaces (BCIs) may integrate AI with the human brain, enabling enhanced cognitive functions and new ways of interacting with the digital world.
8. **AI for Global Equity**
   - Bridging the Digital Divide: AI systems will work to close the gap in digital literacy and technology access, empowering underserved communities worldwide.
   - Equitable Access: Future advancements in AI will focus on democratizing access to healthcare, education, and economic opportunities, ensuring no one is left behind in the digital transformation.

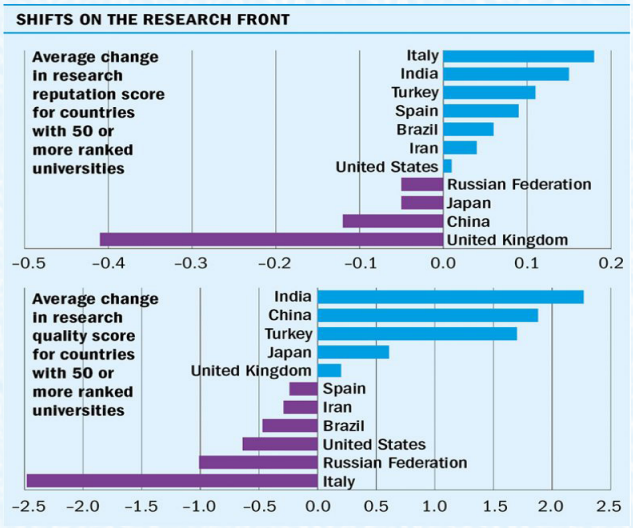
Experts predict the Internet will become 'like electricity' — less visible, yet more deeply embedded in people's lives for good and ill

Source: *https://www.pewresearch.org/internet/2014/03/11/digital-life-in-2025/*

The future of AI holds immense promise, offering transformative possibilities across all sectors of society. From healthcare and education to space exploration and sustainability, AI has the potential to create a more equitable, efficient, and resilient world. However, this potential must be carefully managed with robust ethical guidelines, transparent governance, and inclusive innovation strategies for the benefit of humanity.

Conclusion

Higher education institutions are change agents of societal transformation, playing a critical role in addressing global challenges and fostering sustainable development. Through their contributions to education, research, and community engagement, HEIs have the potential to drive transformative change across various global regions. However, realizing this potential requires addressing the challenges faced by HEIs, including institutional resistance, limited resources, and the dominance of Western knowledge systems.



Source: *https://www.timeshighereducation.com/world-university-rankings/world-university-rankings-2025-shifting-patterns*

By fostering collaboration, promoting equity and inclusion, and leveraging innovative pedagogical approaches, higher education institutions can continue to play a central role in shaping a sustainable and inclusive future. The insights from the contexts provided highlight the importance of contextualized governance, active external collaboration, and the integration of sustainability into higher education practices. As the world continues to grapple with complex socio-political challenges, the role of higher education in driving transformative change for a better world through innovation, invention and peace will remain indispensable.

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Empowering Education and Driving Development: Emerging Technologies in Green Structures and Sustainable Buildings

*by **Er. Prabhakar Singh**, Fellow of Eminence of W-AHEAD*
*Former Director General of Central Public Works **Department***

> *The future of development is green, and the future of green is intelligent, adaptive, and inclusive. Emerging technologies in green structures and building systems are no longer futuristic dreams; they are practical, scalable solutions available today. When these technologies are combined with empowered education, they create a powerful synergy: learners become innovators, classrooms become laboratories, and buildings become beacons of sustainability.*

In an era defined by climate change, rapid urbanization, and resource scarcity, the built environment stands at a critical crossroads. Buildings account for nearly 40% of global energy-related carbon emissions and consume vast amounts of water, materials, and energy over their lifecycle. At the same time, education remains one of the most powerful levers for long-term development, especially when it is aligned with sustainable innovation. The convergence of education and green building technologies offers a transformative pathway: empowering learners with knowledge while driving tangible progress in sustainable development.

This article explores how emerging technologies in green structures and green building systems are reshaping the way we design, construct, maintain and operate buildings. It also highlights how integrating these technologies into education—through curricula, research, and community engagement—can amplify their global impact and foster a new generation of sustainability leaders.

The Urgency of Green Buildings:

The construction, maintenance and operation of buildings place enormous pressure on natural resources and ecosystems. Conventional construction relies heavily on energy-intensive materials like cement and steel, often sourced through environmentally damaging processes. Operational energy for heating, cooling, lighting, and appliances further adds to the carbon footprint, especially in regions with high cooling demands like South Asia.

Green building, or sustainable construction, seeks to minimize this impact by focusing on energy efficiency, water conservation, use of renewable materials, waste reduction, and occupant well-being. Over the past two decades, green building rating systems such as LEED (Leadership in Energy and Environmental Design), BREEAM, and India's own GRIHA and IGBC have helped mainstream sustainable design principles. However, the real game-changer today lies in emerging technologies that are making green buildings not only more efficient but also more intelligent, adaptive, and regenerative.

Emerging Technologies in Green Structures :

Several cutting-edge technologies are redefining what is possible in green structures. These innovations are not just about reducing harm; they are about creating buildings that actively contribute to environmental restoration and community resilience.

1. **Smart Building Management Systems (BMS):**

   Modern green buildings are increasingly equipped with intelligent building management systems that use sensors, IoT (Internet of Things), and AI to monitor and optimize energy use in real time. These systems adjust lighting, HVAC (heating, ventilation, and air conditioning), and shading based on occupancy, weather, and time of day, significantly reducing energy

consumption. For example, AI-driven predictive controls can pre-cool a building during off-peak hours when electricity is cheaper and cleaner, thereby lowering both cost and carbon emissions.

2. **Passive Design and Advanced Envelope Technologies :**

   Passive design strategies—such as orientation, natural ventilation, daylighting, and thermal mass—are being enhanced with new materials and technologies. Phase-change materials (PCMs) embedded in walls or ceilings absorb and release heat, stabilizing indoor temperatures. Vacuum-insulated panels (VIPs) and aerogel-based insulation offer extremely high thermal resistance in thin profiles, ideal for retrofitting existing buildings or designing compact urban structures.

3. **Energy-Generating Building Envelopes :**

   Buildings are no longer just consumers of energy; they are becoming mini power plants. Building-integrated photovoltaics (BIPV) replace conventional cladding, windows, or roofing with solar-active surfaces. Transparent solar glazing allows daylight to enter while generating electricity, turning entire façades into energy harvesters. In some pilot projects, solar skins and solar shingles are being combined with aesthetic design, making sustainability visually appealing and commercially viable.

4. **Green and Living Materials :**

   Innovative materials are reducing the embodied carbon of buildings. Cross-laminated timber (CLT) and other engineered wood products are strong, renewable alternatives to steel and concrete for mid-rise structures. Bio-based materials such as mycelium (mushroom-based insulation), hempcrete, and bamboo composites are gaining traction for walls, insulation, and interior finishes. These materials not only sequester carbon but also improve indoor air quality and occupant comfort.

5. **Water-Sensitive and Circular Design :**

   Emerging technologies are making buildings more water-resilient. Rainwater harvesting, greywater recycling, and blackwater treatment systems are now integrated into building designs, especially in water-stressed regions. Smart water meters and leak-detection systems help reduce wastage. At a higher level, circular design principles are being applied: buildings are designed for disassembly, with materials that can be reused or recycled at the end of their life, minimizing construction and demolition waste.

6. **Digital Twins and Building Information Modeling (BIM) :**

   Digital twins—virtual replicas of physical buildings—are revolutionizing how green buildings are planned, constructed, and operated. Using BIM and real-time data, architects and engineers can simulate energy performance, daylighting, and airflow before construction begins. During operation, digital twins enable continuous monitoring and optimization, helping facility managers make data-driven decisions to improve efficiency and sustainability.

Green Buildings as Living Classrooms :

While these technologies are impressive, their true potential is unlocked when they are embedded in education. Green buildings themselves can become powerful teaching tools—"living laboratories" where students, professionals, and communities learn by doing.

1. **Campus as a Sustainability Lab :**

   Universities and educational institutions can lead by example by constructing green campuses. A campus with solar rooftops, rainwater harvesting, green roofs, and smart meters becomes a real-world classroom. Students in architecture, engineering, environmental science, and management can study energy data, analyze water flows, and propose improvements, turning theoretical knowledge into practical skills.

2. **Curriculum Integration :**

   Engineering and architecture curricula must evolve to include green building technologies, life-cycle assessment, and sustainable materials. Courses on building physics, renewable energy integration, and circular economy principles equip students with the tools to design and manage sustainable structures. Case studies of net-zero energy buildings, green retrofits, and community-based green housing projects can inspire students to think beyond conventional practices.

3. **Research and Innovation Hubs :**

   Educational institutions can host research centers focused on green building technologies. These hubs can collaborate with industry, government, and NGOs to develop locally appropriate solutions—such as low-cost passive cooling systems for hot climates, or affordable green housing using local materials. Student-led projects, hackathons, and design competitions can foster innovation and entrepreneurship in the green building sector.

4. **Community Engagement and Skill Development:**

   Green building technologies are not just for high-end projects; they can be adapted for affordable housing and rural development. Educational programs can train masons, electricians, and local entrepreneurs in green construction techniques, such as rammed earth, compressed stabilized earth blocks (CSEB), and solar water heating. This not only creates green jobs but also empowers communities to build resilient, low-cost, and sustainable homes.

Driving Development through Empowered Education :

Empowering education in green building technologies has a multiplier effect on development:

Environmental Impact :

Widespread adoption of green buildings reduces greenhouse gas emissions, conserves water, and protects biodiversity.

Economic Growth :

The green building sector creates new industries and jobs in manufacturing, installation, maintenance, and consulting.

Social Equity :

Affordable green housing improves living conditions, especially for low-income and marginalized communities, while reducing energy bills and health risks from poor indoor air quality.

Resilience :

Green buildings with passive cooling, on-site energy, and water recycling are better equipped to withstand climate shocks and energy disruptions.

When education systems actively promote green building knowledge and skills, they help shift the entire construction ecosystem toward sustainability. This is not just about training a few specialists; it is about creating a culture of sustainability that permeates policy, practice, and public awareness.

A Call to Action for W-AHEAD :

As a global network committed to education and development, W-AHEAD is uniquely positioned to champion this transformation. We can:

- Promote the integration of green building and sustainable design into educational curricula at all levels.
- Support research and pilot projects on emerging green technologies, especially those relevant to developing regions.
- Facilitate knowledge exchange between educators, practitioners, and policymakers through workshops, webinars, and publications.
- Encourage member institutions to adopt green campus initiatives and share best practices.
- Advocate for policies that incentivize green buildings and support capacity building in sustainable construction.

By linking education with emerging green technologies, we can turn buildings from passive structures into active agents of change. Green buildings powered by innovation, designed with intelligence, and maintained by skilled professionals can become symbols of a sustainable future.

Conclusion:

The future of development is green, and the future of green is intelligent, adaptive, and inclusive. Emerging technologies in green structures and building systems are no longer futuristic dreams; they are practical, scalable solutions available today. When these technologies are combined with empowered education, they create a powerful synergy: learners become innovators, classrooms become laboratories, and buildings become beacons of sustainability.

As we look ahead, let us reimagine education not just as a means to understand the world, but as a force to transform it. By empowering learners with knowledge of green building technologies, we are not only constructing sustainable buildings, we are building a more resilient, equitable, and sustainable world for generations to come.

Great Future for Humanity Empowered by Vidya

*by **Dr. Kumar Krishen**, Fellow of Eminence,*
World Academy of Higher Education and Development

> *Great future is hard to pinpoint exactly. Nevertheless, it must include providing needs for the sustenance of life. It should include food, clean water and air, shelter, clothing, resources needed for coping with changes in environment (including seasonal changes), transportation, medication, and hospitals. With the current wars and terrorism, we have added formidable challenges to provide a better quality of life for all. Our changing Earth environment is alarming and needs novel approaches, thereby underscoring the need for knowledge (vidya).*

Introduction

Presently humanity is facing a crisis brought about by global wars and terrorism. The focus of Nations on designing and fabricating weapons of mass destruction has absorbed the attention and resources leading to a dismal situation. The result is human suffering, degradation, and a dismal outlook for the future. The author is of the opinion that destruction as is happening is unsustainable and human desire to live peacefully will enable a change in the direction of working for the betterment of life. This thinking comes from the historic fact, “King Ashoka the great, saw the massive death and devastation after conquering Kalinga (around 260 BCE). He saw dead mothers, children, and ruined homes. This made him to have a change of heart resulting in renouncing the war and dedicating his rule to peace, compassion, and moral conduct (Dharma)”(Refl). There is a belief promoted in ancient Bharat that the author thinks will be accepted by humanity once peace prevails on this globe. It is ,”Vasudhaiva Kutumbakam,” , the world is one family. (Ref. 2). This paper deals with the part that will be played by vidya in empowering humanity to realize a great future.

The Multidimensions of Vidya

A search on Google and Wikipedia gives this , “Vidya encompasses broad concepts of knowledge, learning, wisdom, and understanding, ranging from mundane education (Apara Vidya) to profound spiritual insight (Para Vidya) leading to enlightenment, covering intellectual study, practical skills, and self-realization.” (Ref.3). More dimensionality of Vidya is captured in Wisdom Library, “Vidya or knowledge signifies the ultimate service to Lord Vishnu, going beyond material concerns.” Similarly, in Vedanta, it pertains to the comprehension of the Self (Atman), which is viewed as the essential pathway to achieving the highest bliss. Both perspectives emphasize the spiritual significance of knowledge, highlighting its role in connecting with the divine and attaining deeper understanding and fulfillment.” (Ref. 4).

The author is convinced that vidya is a phenomenological fusion of what a human receives from her/his senses (sight, hearing, smell, taste, and touch). This understanding comes from Bhagavad Geeta (Ref. 5), where (paraphrasing) it is stated that senses are superior to the body, the mind is superior to the senses, the intellect is superior to the mind, and Atma is superior to the intelligence.

So, the mysterious way a human fuses/ processes the information results in the knowledge that she/he acquires. This view of knowledge makes us understand the differing perspectives that humans have of the ‘facts’ presented to them. This understanding is further complicated by knowing that our information is invariably the tip of the iceberg (photo on right). This elucidates the power of using metaphysical capability to know more than is possible with our intelligence. This attribute is more than what is added to

knowledge with experience and wisdom.

Guru Vishnusharman, known for his worldly wisdom, expounded the niti-shastra (roughly translated it means, wise conduct of life) in stories contained in the Panchatantra, published in about 200 BC. The author presents (given on the right side) the expose of genuine intelligence, wisdom, and right deeds from the translation of this book by Prof. Arthur Ryder (Ref 6). The attributes/deedsfor these human endeavors are fully specified by these poetical expressions.

The wise in need still does the deed That keeps his honor bright: The shell a peacock ate and dropped, Remains a pearly white. Do the right, the right, the right, Till the breath of death; Shun the wrong, although the right Lead to death of breath." The first or second evidence Of genuine intelligence Is—leave a business unbegun, Or, if begun, then see it done.

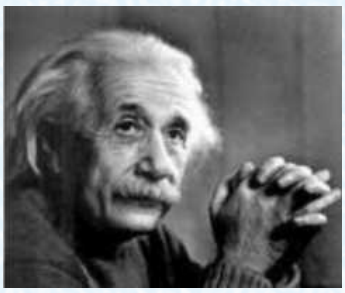
When we examine Pramanas, means of achieving true/accurate knowledge, we get more appreciation of the multidimensional aspects of vidya. The six main Pramanas (as per Nyaya & Vedanta) (Ref. 7) are as follows: Pratyaksha (Perception): Knowledge gained by the senses. Anumana (Inference): Knowledge derived from reasoning or logical deduction. Shabda (Verbal Testimony): Knowledge from reliable sources/scriptures / experts. Upamana (Comparison / Analogy): Knowledge gained by understanding similarities or comparison with a known example. Arthapatti (Postulation/ Presumption): Deducing something from existing facts or situation. Anupalabdhi (Non-Perception / Negative Proof): Knowledge of something's absence.

Artificial intelligence (AT) has found great applications in almost all human endeavors and will be included in the next Section of this paper. AI refers to the ability of computer systems, machines, and robots to perform tasks that typically require human intelligence (photos on left from internet and right NASA Robonaut from NASA). The author calls AI Transferred Intelligence (TI). The process of transferring intelligence includes these steps: 1) Humans research complex phenomena, events, and problems. 2) Humans find solutions and develop models. 3) Humans develop dependable, cost effective, and safe computer systems, machines, and robots. 4) Humans program these machines with models so that independent performance can be achieved.

In short, the computer systems, machines, and robots know how to and can do complex tasks with precision night and day. However, there are limitations to what these substitutes for humans can do. It is a lengthy topic and cannot be accommodated in this short paper. (Ref 8).

Education is the life-long acquiring of knowledge, skills, values, and character. Swami Vivekananda says, "We want that education by which character is formed." Thus, education must teach ethical use of knowledge. This author believes that truly educated humans promote hope, peace, and prosperity through their work. Thus, vidya empowers people to research science and technology innovations (including systems, techniques, methods, and protocols) for the betterment of humanity.

The Need for Science, Innovation, and Technology



From time immemorial, humans have survived on this Earth by identifying and practicing the ways that can enable a healthy lifestyle. In this brief paper, the author will give some examples of future research and innovation needs empowered by vidya. At a higher level, humans are always engaged in expanding the boundaries of knowledge to understand the birth, existence, and extinction processes of the universe (s). This presents one of the greatest challenges of all times. This includes the understanding of time, space, energy, matter, life, and 'nothing'. The ancient Vedic Concept of time (Kala) states that it is

the power that limits the existence of eternal elements in matter. The smallest time is called Truti (one-tenth of a nanosecond) and the longest time when everything is destroyed (Maha pralaya), is 3.1415..(pi) trillion years.

After this, the new cycle begins (Ref. 9). So, time is periodic and always present. The quest for knowing what is beyond our universe will always continue. This quest for knowledge is supported by two quotes of Nobelist Albert Einstein (photo on right): 1) “The mysterious is the true source of all art and science.” 2) “Imagination is more important than knowledge.

Space exploration and development will take advantage of prominence as this enterprise will yield great economic benefits. One example where science and technological innovations are critical is human exploration of Mars. This is deemed as the most challenging mission by many nations. Innovations will be needed in many areas including recycling resources with concern for germs and other harmful substances and using resources provided on Mars. Other areas include: air production, harvesting frozen water logged in the soil of Mars, Mars soil and topology investigation, solar power; Mars lighting conditions; Mars temperature; Mars dust and dust storms; cosmic radiation and nuclear particle environment on Mars; Mars gravity (38 % of Earth); production of needed consumables; for example, air, water, food, clothing; recreation and sports for health; reproduction/hospital facilities for sustained human settlement; facilities for handling deceased persons; broadband communication with Earth on a 24 hour basis; environmental monitoring facilities and warning systems; and rules and laws that allow orderly living with law enforcing Agents. We will be building on the experience that we have gained from all previous human space missions but clearly there is need for new technologies and approaches to make such a mission extending to more than two and a half years successful.

The author continues to research as to how old homosiepians are on this. Ere are some results: Animal Life - 50 to 100 million years, Homo Sapiens - 195,000years (Lower OMO Valley of Ethiopia, Skeletally Modern Looking Homo Sapiens- 50,000 years; Fossil remains of Homo sapiens, 315,000 years, found at a site in Jebel Irhoud, Morocco. From Google search, we have, “The oldest evidence for human (hominin) activity includes Oldowan stone tools from Ethiopia/Gona (around 2.5-2.6 million years old) and fire/tool use at South Africa’s Wonderwerk Cave (1.8 million years old). For anatomically modern humans (Homo sapiens), the oldest skeletal remains are found in Africa, with sites in Ethiopia (Omo) and Morocco (Jebel Irhoud) yielding fossils around 233,000 to 315,000 years old.” (Ref 10).

In this tapestry of pieces of puzzle as evidence for human life, we have a photo taken by NASA (side) from satellite. The legends, as well as Archeological studies reveal that the first signs of human inhabitants in Sri Lanka date back to a primitive age, about 17,50,000 years ago and the bridge’s age is also almost equivalent, [source Internet]. This evidence, per this author, is a profound finding, pointing that life flourished about 1.75 million years ago in Bharat and Sri Lanka. Thus, we need to continue the research for the origin of life on Earth.

Let us turn to some high-level needs for the prediction of and recovery from the natural changes of Earth (as a planet in our Universe). Natural causes for Earth changes include, Asteroid (s) hitting Earth, Volcanoes, Platelet Motion, Earthquakes, Tsunamis, Natural Fires, Hurricanes, Floods, Sink Holes, Tornados, and Sandstorms. The consequences of human activity needing innovative science and technology include human made disasters, lack of resources for a better quality of life, problems associated with increased population, pollution, congestion, global warming, and need for reconstruction (resulting from global wars, and terrorism). Alleviating human ailments provide great challenges include, viruses related ailments, cancer, brain, and heart related diseases.

The author is continuing to investigate promising innovative technologies that have potential for applications here on Earth and for the space exploration and development. The list of technologies that he is presently investigating is as follows: Quantum Vacuum Plasma

Thruster (Q-Thruster) Technology; Variable Specific Impulse Magnetoplasma Rocket (VASIMR®) Engine; Habitation Wastewater Recovery Technology; Biodigesters: Waste-to-Fertilizer Conversion Technology; Laser Processed Heat Exchangers; In-Situ Resource Utilization Technology (Methane Production, Water Processing, Oxygen Production); Augmented Reality Environment for Human Mission Applications; Expandable Structures/ Habitats; Shape-Morphing Adaptive Radiator Technology; Effects of Dust and Dust Storm Alleviating/Reducing Technology/Systems; Wavelet Technology; Advanced Space Suit Technology; New Sensor Technology for Temperature, Atmosphere, and Gases, Biological -Human Health; Autonomous Systems (Fuzzy logic, Deep learning, Neural Networks); Carbon Nano Technology (Coatings, Composite structures, and electronics); Ionic Polymer Metallic Composite Technology Intelligent/ Smart Materials (Actuators and sensors); Superconductor Technology; and Tera Hertz Technology.

Concluding Remarks

Human efforts will find acute demand in providing a great future. Great future is hard to pinpoint exactly. Nevertheless, it must include providing needs for the sustenance of life. It should include food, clean water and air, shelter, clothing, resources needed for coping with changes in environment (including seasonal changes), transportation, medication, and hospitals. The present population of the world is over eight billion. Roughly 10 % of this population lives in poverty. With the current wars and terrorism, we have added formidable challenges to provide a better quality of life for all. Our changing Earth environment is alarming and needs novel approaches, thereby underscoring the need for knowledge (vidya). The author (see right side sketch as given in the article) was interviewed for a Prestige Magazine article titled, "Panacea for a changing world? ". The author was asked as to why space exploration and development is important for humanity. The author answered thusly(Prestige 2012, Page 56): "The environment on earth will change drastically in the far future. Places which are habitable at this time may be under water or ice or may become deserts or mountains. The methods we will then use will be hugely impacted by the space exploration programmes we have completed."

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Role of Biofuels for India's Clean Energy Transition

*by **Prof (Dr) H R P Yadav,** FIE, FWAPS, FW-AHEAD*
Secretary General , W-AHEAD

> ***Using biofuel like bioethanol and biodiesel as renewable energy can help reducing green house gas emissions and achieve climate targets by 2050, However, the challenges to create infrastructure for harnessing renewable energy sources need to be addressed by the policy makers.***

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INTRODUCTION :

Due to the increasing trend of green house gases (GHGs) after burning of fossil fuels , the global climate change impacts are affecting the environment, ecology , flora and fauna . The fossil fuels in the transportation, thermal power generation and other man-made activities create carbon footprints, and the built -environment becomes carbonized. There has been huge challenges in the environment, such as air and water pollution, waste disposal, electricity generation with carbon emissions. To address these challenges, Government of India have taken some key initiatives like bio-fuel policy, green hydrogen mission, net zero emission by 2030, 500 GW power generation from renewable energy by 2030 . The Hon'ble Union Minister of Petroleum and Natural Gas during India Energy Week held in February 2025 at New Delhi stated that there has been a link between economic activity and energy use and there will be requirement of more energy as time passes from $ 4 trillion to $ 10 trillion economy and beyond. India is moving ahead on sustainable aviation fuel (SAF). It is preparing the ground for biofuels to be integrated into its supply chain . India has set a target of 5% blending in SAF mandatory by 2030 and there is an opportunity for the export of the fuel of the future . India is also striving to increase the share of gas in the economy to 15 per cent from six per cent .Apart from this ,India has also set a target of production of five million metric tons of green hydrogen annually.

SUSTAINABLE BIOFUEL OPPORTUNITY FOR INDIA'S ENERGY TRANSITION:

As India has entered into the transitions towards a cleaner and more sustainable energy solutions, the role of biofuels has emerged as a critical component in reducing carbon emissions and mitigating threat of energy security. Its adoption of biofuels in the energy mix across the globe has been muted as it still faces scrutiny regarding food security, higher costs, and deforestation.

The Global Biofuels Alliance (GBA) roundtable at India Energy Week 2025 brought together policymakers, industry leaders and international organizations to address the pressing need for harmonised sustainability criteria for biofuels.

The leaders called for collaborative action to develop transparent, inclusive, and adaptable sustainability frameworks, which would enable sustainable biofuels' broader adoption and long-term success.

The industry's huge potential, including its ability to decarbonise and deliver one-third of today's natural gas consumption and reduce global greenhouse gas emissions by 11 percent has also been considered as one of the positive steps towards net zero emissions drive by 2030. Charlotte Morton Chief Executive of the World Biogas Association, however, has said that there are many challenges due to the lack of acceptability and acknowledgement of biofuels and various discouraging statements about bioenergy.

The biofuels industry is seeking the rightful place in the global energy dialogue. They are critical to decarbonising hard-to-abate sectors like transportation, aviation, shipping, and heavy industries.

Roberto Bocca, Head, Centre for Energy and Materials, and Member of the Executive Committee at World Economic Forum said that the future of bioenergy systems is more complex because they bring more opportunities. More opportunities mean more complexities, meaning infrastructure investment will depend on clarity.

"So, it is critical that we understand the direction, size, volume, and not just the taxonomy but also the potential of these different solutions. This will mean the investments can flow more confidently," said Bocca.

Over a year after the inception of GBA, led by the US, Brazil, and India, the alliance has expanded to include 28 countries and 12 organisations, including the World Bank, the World Economic Forum, and the International Energy Agency. It is playing a pivotal role in increasing the adoption of sustainable biofuels on the global stage.

The joint collaborative efforts by the industry and academia on sustainable biofuels emphasised a shared commitment to accelerating biofuel development, adoption, and integration into the global energy mix, emphasising international cooperation, policy support, and technological advancements.

The Policymakers also explored the potential of non-food feedstocks in advancing India's biofuels sector, key opportunities, challenges, and policy considerations for scaling sustainable biofuels and strengthening energy security.

BIOFUEL FOR SUSTAINABILITY:

Using agriculture residue for ethanol and SAF production also addresses the problem of stubble burning and allows farmers to generate additional income from waste. It is just one of the agricultural residues (including maize, sugar, used cooking oil, besides municipal waste) that can be supplied as sustainable fuels to the industry. Alternate feedstock, such as sweet sorghum, seaweed, and reusable plastic waste, can give further impetus to SAF's potential in the country.

As the world shifts to optimal use of all resources, municipal solid waste could be a key input for SAF. Its potential could further increase with higher solid waste generation, better segregation capabilities, and higher diversion of SAF production. Using agriculture residue for SAF production also addresses the problem of stubble burning and enables farmers to generate additional income from waste.

According to initial industry estimates, by 2040, India will have the opportunity to produce 8–10 million tonnes of SAF against the potential demand of around 4.5 million. By then, the SAF blending rate is seen at 15 percent. An estimated 230 million tonnes of surplus agricultural residue are unused and could also be used for the 2G ethanol plants being set up by the oil marketing companies.

SAF production in 2024 was around 1 million tonnes. According to IATA, SAF demand is expected to hit 50 million tonnes by 2050. With the right regulation, technologies, demand from consumers, and feedstock for production, could help create a new industry.

Vision 2040 for India's aviation sector has estimated passenger traffic at 1.1 billion and freight traffic at 1.7 million tonnes. India currently accounts for a little over two percent of the global ATF demand. Given India's abundant feedstock for SAF and high exposure to exports for ATF (50 percent of ATF produced being exported), India is well-positioned to capitalise on the rising global demand for SAF.

2G ETHANOL PLANTS FOR BIOFUEL PRODUCTION:

2 G ethanol plant produces ethanol using non-food biomass like agriculture waste, such as rice straw or sugarcane bagasse in place of food crops like corn or sugarcane. 2G ethanol plants are designed to utilize technologies like pre-treatment, hydrolysis and co-fermentation to convert biomass into ethanol, biogas and even bio-CNG. The production process involves pre-treatment to break down biomass, hydrolysis to convert complex carbohydrates into simpler sugars and fermentation to produce ethanol.

Fig: 2G Biofuel (ethanol) Production Plant

BENEFITS OF 2G PLANTS:

2G ethanol production reduces the dependence on food stocks for biofuel production. It utilizes wastes from agriculture resources and contribute to a sustainable and circular economy principles. Government of India has been promoting 2G ethanol through the schemes like the Pradhan Mantri Jivan Yojana offering financial support and incentives to the prospective industry.

CONCLUSION:

Using biofuel like bioethanol and biodiesel as renewable energy can help reducing green house gas emissions and achieve climate targets by 2050, However, the challenges to create infrastructure for harnessing renewable energy sources need to be addressed by the policy makers. Biofuels can reduce dependence on fossil fuels particularly in transport sector.

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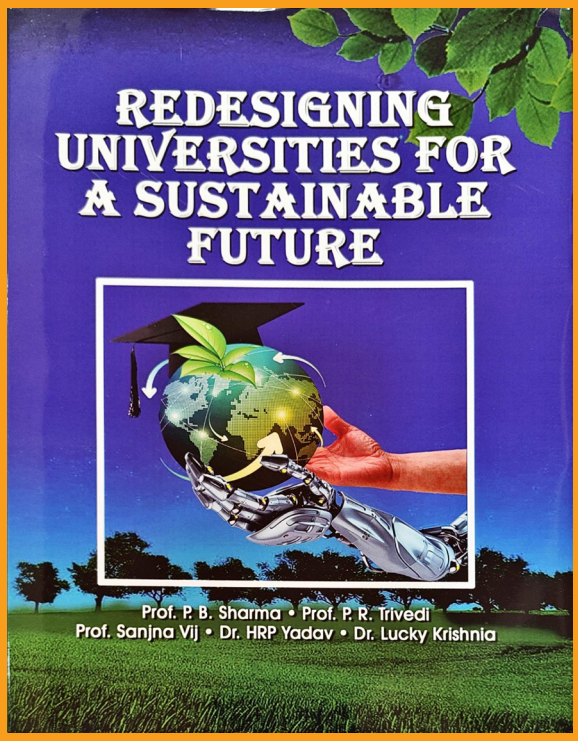

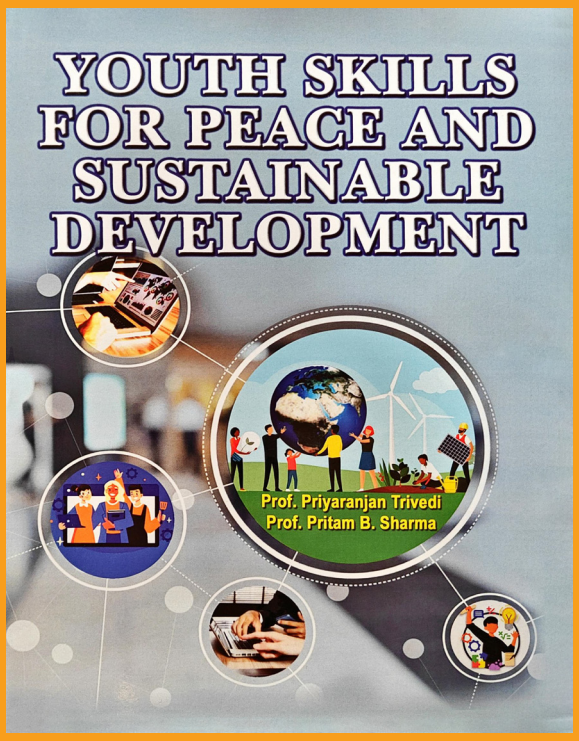

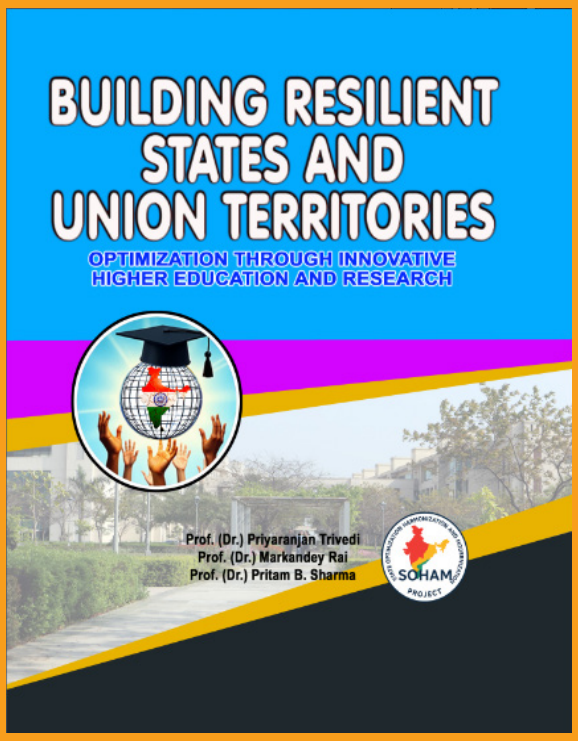

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