March 2026

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

International E-Research Journal

Peer-Reviewed, Open-Access Journal

Volume - 2, Issue 7 (Special Issue)



Publisher-

Dr. Bhausaheb Y. Deshmukh

Principal, Adv. M. N. Deshmukh Arts, Science & Commerce College, Rajur, Ahilyanagar, Maharashtra

Chief Editor -

Dr. Rajendra Dandwate

Professor, Arts, Commerce and Science College, Sonai, Ahilyanagar, Maharashtra

Website: https://www.ijitmr.com

Email: editor@ijitmr.com

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

E-ISSN: 3049-3846

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Executive Editor -

Dr. Sunita Dandwate

Assistant Professor,
Sanjivani College of Engineering,
Kopargaon, A.Nagar, Maharashtra

Chief Editor -

Dr. Rajendra Dandwate

Professor,
Arts, Commerce and Science College,
Sonai, A.Nagar, Maharashtra

Co-Editors

- Dr. WAHP, Guruge, Professor in Zoology, Faculty of Science, University of Ruhuna, Matara, Sri Lanka University of Ruhuna, Sri Lanka
- Dr. Sudeep Thakuri, Associate Professor, Faculty of Science & Technology Mid-West University, Surkhet, Nepal
- Dr. Arvindan Balakrishnan, Professor, English unit, Prepatory Studies Centre, University of Technology, Applied Sciences, Nizwa, Sultanate of Oman
- Dr. Rajendra Prasad Singh, Professor Civil Engineering, School of Civil Engineering, Southeast University, (SEU), Nanjing China
- Dr. Vidydevi Patil, Assistant Professor, Department of Applied Sciences, SRE's Sanjivani College of Engineering, Kopargaon, Ms. India
- Dr. Anil Kumar, Assistant Professor, Sociology & Public health, Shri Ramswaroop Memorial University, Lucknow
- Dr. Balasaheb Kacharu Tapale, Assistant Professor and Head, Department of Zoology, Adv. M. N. Deshmukh Arts, Science and Commerce College Rajur
- Dr. Deepmala Babasaheb Tambe, Associate Professor and PG Incharge, Department of Botany, Adv. M. N. Deshmukh Arts, Science and Commerce College Rajur

Advisory Board

- Dr. Kiran Bamel, Associate Professor, Botany, Shivaji College, University of Delhi.
- Dr. Sreebha, Assistant Professor, Botany, V. V. Vanniaperumal College for Women, Virudhunagar, Tamil Nadu.
- Dr. Rohit Shankar, Professor, Sericulture, Yuvaraja's College Mysuru
- Dr. Ravi G. Pradhan, Professor, Zoology, LBS College Partur, Ms
- Dr. Sharad G. Jagtap, Associate Professor, Zoology, Late K.G. Katariya College, Daund Ms
- Dr. M. J. Shaikh, Associate Professor, Zoology, ACS College Sonai, Ms. India
- Dr Meera Srivastva, Rt. Principal, Govt. College, Lunkaransar, Bikaner Rajasthan
- Prof. Rohit Chandrakant Muthe, Assistant Professor and PG Incharge, Department of Chemistry, Adv. M. N. Deshmukh Arts, Science and Commerce College Rajur
- Prof. Babasaheb Haridas Telore, Assistant Professor, Department of Political Science, Adv. M. N. Deshmukh Arts, Science and Commerce College Rajur
- Prof. Sukdeo Thorat, Assistant Professor, Department of Physics, Adv. M. N. Deshmukh Arts, Science and Commerce College Rajur

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

INDEX

Sr. No.	Title of the Paper	Author's Name	Page No.
1	Sustainable Development in Higher Education	Miss. Rekha Appasaheb Kadhane	6
2	Sustainable Financing and Higher Education	Dr. Aswale Santosh Radhakisan	11
3	Research and Innovation for Sustainability	Prof. Parate Santosh Shravana	17
4	Role of Indian Higher Education in Achieving Sustainable Development Goals	Mr. Ganesh S. Kusmude	22
5	Globalization and Knowledge Sharing	Prof. Dr. Sonawane Rajaram Ramdas	25
6	Education for Sustainable Development: Building Knowledge for Sustainable Future	Mr. Tambe Yogesh Bapusaheb	32
7	Challenges and Opportunities of Sustainable Financing in Higher Education	Mr. Nitin Baban Shende	36
8	Sustainable Development Goal 4 (SDG-4) and the Transformation of Higher Education in India: Policy Reforms and Budget 2026 Initiatives	Dr. Vidya M. Jirage	44
9	Sustainable Financing and Higher Education	Pratiksha Ansurkar	53
10	The role of Higher Education in Vikashit Bharat @2047: Inclusive sustainable development	Dr. Ashok Shankarrao Pawar, Prof. (Dr.) Bhausaheb Y. Deshmukh	64
11	Education for Sustainable Development	Mr. Kokare Krishna Vitthal	88
12	A Study on Sustainable Development through Education: Opportunities and Challenges	Seema Badiger	94
13	Pedagogical Innovations in Higher Education for Sustainable MSME Development	Sharad J Bikkannavar	99
14	Role of Hydrogen Energy in India's Net-Zero Carbon Goals	Prof. Sanjay Dhondiba Kadlag	109

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

15	Farmer Producer Companies as Catalysts for Sustainable Rural Development: A Study of North Maharashtra	Mr. Sachin Ramdas Kolhe and Prof. Dr. Ganesh Raosaheb Patil	114
16	Role of Entomology in Higher Education and Sustainable Development	Rajendra Navnath Kasar, Dnyaneshwari Sudhir Godase	124
17	Study of Beetle Diversity in Paddy Fields Dhamanvan Region, Akole Taluka	Varsha Raghunath Baramate	129
18	Academic Libraries and Knowledge Sharing in Indian Higher Education: An Overview	Yogita Wakchaure	135
19	शाश्वत विकासात उच्च शिक्षणाची भूमिका: एक अर्थशास्त्रीय अभ्यास	डॉ. विश्वनाथ गजानन कोटकर	143
20	जागतिकीकरण आणि ज्ञानाची देवाणघेवाण	विकास बाळासाहेब पावसे आणि डॉ.एल.जी.रेटवडे	150
21	शिक्षण आणि शाश्वत विकास : एक अभ्यास	प्रा. डॉ. धनराज सुभाष हाडुळे	155
22	Synthesis of highly conductive Polymer Pedot: PSS by surfactant templates: An Innovative Approach	Akshay R. Mundhe, Rohit C. Muthe and Ashwini S. Gandal	163
23	Changing Political Scenario of Tribal Communities in Ahmednagar	Prof. Telore Babasaheb Haridas	174
24	Growth of Start-Up Ecosystem in India: Opportunities and Challenges	Sindhu M.R	180
25	Role of Life Sciences in Higher Education and Sustainable Development	Dr. Balasaheb K. Tapale	189
26	जागतिकीकरण आणि तांत्रिक ज्ञानाचे हस्तांतरण : उदयोन्मुख अर्थव्यवस्थांचा अभ्यास	प्रा. डॉ. नितीन उल्हास देशमुख	194
27	Green Campuses and Sustainable Universities: Institutional Practices for Environmental Responsibility	Mr. Santosh D. Chippadi and Mr. Basavaraj Dhavaleshwar	204
28	शाश्वत विकासासाठी उद्योजकतेचे योगदान	डॉ.मोहन बळीबा शिंदे	219
29	Roots and Tubers as Fundamental Food Found in Akole Taluka, District Ahilyanagar, Maharashtra State	Prachi Sharad Kondar and Dr. D.B.Tambe	230
30	Challenges in Higher Education for Sustainable Development	Shraddha Bhausaheb Bagad	245

31	Use of AI in Chemistry For Sustainable Development	Onkar P. Bangar, Rohit C. Muthe	258
32	Solvent-Free Microwave-Assisted One-Pot Synthesis of Phthalocyanine Copper (II) (CuPc) Complex	Onkar P. Bangar, Rohit C. Muthe, Ashwini S. Gandal	264
33	Phytochemical Analysis of Arisaema Murrayi and Its Characterisation	Onkar P. Bangar, Rohit C. Muthe, Akshay R. Mundhe	271
34	Renewable energy resources: Current status, Future Prospects and their Enabling Technology	Shital M. Bhoir	282
35	Integrating Sustainability into Higher Education Curriculum	Prof. Manasi Milind Pawar	305

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

SUSTAINABLE DEVELOPMENT IN HIGHER EDUCATION

Miss. Rekha Appasaheb Kadhane
Faculty Incharge & HOD Commerce,
Adv. M. N. Deshmukh Arts, Science and Commerce College Rajur,
Tal-Akole, Dist-Ahilyanagar
Affiliated to Savitribai Phule Pune University
Cell-9860149323,
E-mail- rekhakadhne@gmail.com

Abstract:

Sustainable development has become an important objective for educational institutions worldwide. Higher education institutions play a vital role in promoting sustainability by integrating environmental, social, and economic principles into teaching, research, and institutional practices. Universities act as catalysts for innovation, awareness, and policy development that support sustainable development. The purpose of this research paper is to examine the role of higher education institutions in promoting sustainable development, identify challenges in implementing sustainability initiatives, and suggest strategies for improving sustainability practices. The study is based on secondary data collected from academic journals, books, and institutional reports. The findings indicate that integrating sustainability into curriculum, campus operations, and research activities can significantly contribute to achieving sustainable development goals. However, lack of awareness, financial constraints, and institutional resistance remain key challenges. The study suggests policy reforms, curriculum redesign, and stronger institutional commitment to sustainability.

1. Introduction

Sustainable development is a concept that focuses on meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. It combines three major pillars: environmental protection, economic growth, and social equity.

Higher education institutions play an important role in shaping sustainable societies by providing education, conducting research, and influencing social values. Universities have the responsibility to prepare students with the knowledge, skills, and attitudes necessary to address environmental challenges, climate change, poverty, and inequality.

Education for Sustainable Development (ESD) emphasizes the integration of sustainability concepts into academic curricula, research activities, and campus management practices. Universities worldwide are increasingly adopting sustainability initiatives such as green

campuses, renewable energy projects, waste management systems, and sustainability-focused courses.

In India, the role of higher education in promoting sustainability is gaining importance due to environmental challenges such as pollution, resource depletion, and climate change. Therefore, integrating sustainable development principles into higher education is essential for building a responsible and environmentally conscious society.

2. Review of Literature

2.1 Brundtland Commission (1987)

The Brundtland Commission introduced the concept of sustainable development and emphasized the importance of integrating environmental protection with economic and social development.

2.2 Sterling (2004)

Sterling highlighted the need for transformation in higher education systems to incorporate sustainability concepts into teaching and learning processes.

2.3 Lozano (2011)

Lozano studied sustainability initiatives in universities and found that higher education institutions play a key role in promoting environmental awareness and sustainable practices.

2.4 Barth and Rieckmann (2016)

The researchers emphasized that universities must focus on developing sustainability competencies such as critical thinking, problem-solving, and systems thinking among students.

2.5 UNESCO (2020)

UNESCO emphasized the importance of Education for Sustainable Development (ESD) in achieving global Sustainable Development Goals (SDGs).

The literature suggests that universities must actively integrate sustainability into academic programs, research, and campus operations to contribute effectively to sustainable development.

3. Objectives of the Study

The main objectives of this research are:

1. To understand the concept of sustainable development in higher education.
2. To analyse the role of universities in promoting sustainable development.
3. To identify challenges faced by higher education institutions in implementing sustainability practices.
4. To suggest measures for strengthening sustainable development initiatives in higher education.

4. Hypothesis of the Study

H1: Higher education institutions play a significant role in promoting sustainable development.

H2: Integration of sustainability in curriculum positively influences students' environmental awareness.

H3: Institutional support and policies significantly impact the success of sustainability initiatives in universities.

5. Research Methodology

5.1 Nature of Research

The study is descriptive and analytical in nature.

5.2 Sources of Data

The study is based on **secondary data** collected from:

- Research journals
- Books
- Government reports
- Educational websites
- Academic databases

5.3 Research Approach

The research analyses existing literature and reports related to sustainable development in higher education.

6. Role of Higher Education in Sustainable Development

Higher education institutions contribute to sustainable development in the following ways:

6.1 Curriculum Development

Universities introduce sustainability-related subjects such as environmental management, sustainable business practices, and climate studies.

6.2 Research and Innovation

Research conducted by universities helps develop solutions for environmental problems, renewable energy, sustainable agriculture, and resource management.

6.3 Sustainable Campus Practices

Many universities adopt green campus initiatives such as:

- Energy conservation
- Waste recycling
- Water conservation
- Eco-friendly infrastructure

6.4 Community Engagement

Universities collaborate with local communities and organizations to promote environmental awareness and sustainable practices.

7. Challenges in Implementing Sustainable Development in Higher Education

Challenges	Description
Lack of Awareness	Many institutions lack awareness about sustainability education
Financial Constraints	Limited funding for sustainability projects
Curriculum Limitations	Traditional education systems focus on theoretical knowledge
Institutional Resistance	Resistance to change in academic structures

8. Findings of the Study

1. Higher education institutions play an important role in promoting sustainable development.

2. Sustainability education helps students develop environmental awareness and responsible behavior.
3. Universities that integrate sustainability into curriculum and campus management achieve better sustainability outcomes.
4. Financial constraints and lack of institutional commitment are major barriers to sustainability implementation.

9. Suggestions

1. Universities should integrate sustainability topics across all academic disciplines.
2. Government should provide financial support for sustainability initiatives in higher education.
3. Institutions should develop green campus policies.
4. Faculty members should receive training on sustainability education.
5. Universities should collaborate with industries and NGOs for sustainability projects.

10. Conclusion

Sustainable development has become an essential objective for modern societies. Higher education institutions play a crucial role in achieving sustainability by educating future leaders and professionals. Universities can contribute to sustainable development through curriculum innovation, research activities, campus management practices, and community engagement.

However, several challenges such as lack of awareness, limited resources, and institutional resistance hinder the implementation of sustainability initiatives. By adopting appropriate strategies and policies, higher education institutions can become powerful agents of sustainable development and contribute significantly to achieving global sustainability goals.

12. References

1. Brundtland Commission (1987). Our Common Future.
2. Sterling, S. (2004). Higher Education and Sustainability.
3. Lozano, R. (2011). The State of Sustainability in Universities.
4. Barth, M., & Rieckmann, M. (2016). Academic Staff Development for Sustainability.
5. UNESCO (2020). Education for Sustainable Development Goals.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

SUSTAINABLE FINANCING AND HIGHER EDUCATION

Dr. Aswale Santosh Radhakisan
Adv. M.N. Deshmukh Arts, Science and Commerce College, Rajur
Tal.- Akole Dist. Ahilyanagar, 422604
Mob. No. 97661512978
Email- aswalesantosh123@gmail.com

Abstract:

Sustainable financing has become an essential component in ensuring the long-term development and stability of higher education institutions. With the increasing demand for quality education, universities and colleges require stable and diversified funding sources to maintain academic programs, research activities, and infrastructure development. Sustainable financing focuses on long-term financial strategies that combine government funding, private investments, tuition fees, and innovative financial instruments. It also promotes efficient resource allocation, transparency, and accountability in educational institutions. This research paper explores the concept of sustainable financing, its importance in higher education, major funding sources, challenges faced by institutions, and strategies for achieving sustainable financial systems. The study highlights how sustainable financing supports educational development, innovation, and social equity while ensuring the continued growth of higher education systems worldwide.

1. Introduction:

Higher education plays a crucial role in the social, economic, and technological development of a country. Universities and colleges produce skilled professionals, conduct research, and contribute to innovation and national development. However, the rapid expansion of higher education systems across the world has created significant financial challenges. Institutions must invest in infrastructure, technology, research facilities, and qualified faculty while maintaining affordable education for students.

Sustainable financing refers to financial strategies that ensure educational institutions have sufficient resources to operate effectively in the long term. It involves generating adequate revenue while maintaining financial stability and supporting institutional goals. According to international educational organizations, financing higher education includes multiple sources such as government funding, tuition fees, private donations, and partnerships with industries.

In recent years, governments and educational institutions have recognized that traditional funding models alone cannot meet the increasing financial demands of higher education. As a result, new approaches such as public-private partnerships, green finance initiatives, and outcome-based funding mechanisms are being introduced. Sustainable financing aims not only to provide financial resources but also to ensure that education systems remain accessible, equitable, and capable of addressing future challenges.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

2. Concept of Sustainable Financing in Higher Education:

Sustainable financing refers to the ability of higher education institutions to generate sufficient financial resources to maintain operations, invest in future growth, and deliver quality education over time. Financial sustainability ensures that institutions can recover their operational costs while investing in infrastructure, human resources, and innovation.

A financially sustainable higher education system usually includes three major elements:

1. **Long-term strategic planning**:

Institutions must have clear goals and strategies that guide their financial planning and investment decisions.

2. **Adequate revenue generation**:

Universities require diversified income sources to support teaching, research, and administrative activities.

3. **Efficient financial management**:

Effective budgeting, accountability, and transparent financial systems help institutions use resources wisely.

Sustainable financing is closely connected to global development goals. For example, international initiatives emphasize the importance of investment in education to ensure inclusive and equitable quality education for all learners.

3. Importance of Sustainable Financing in Higher Education:

Sustainable financing is essential for the development and stability of higher education systems. Without adequate financial resources, universities cannot maintain quality education, research activities, or technological advancements.

3.1 Ensuring Quality Education:

Adequate funding allows institutions to hire qualified faculty, develop modern curricula, and provide advanced learning facilities. Financial stability ensures that educational programs remain competitive and relevant.

3.2 Supporting Research and Innovation:

Research activities require significant investment in laboratories, equipment, and human resources. Sustainable financing enables universities to conduct research that contributes to scientific advancement and economic development.

3.3 Expanding Access to Education:

Financially stable institutions can provide scholarships, financial aid, and affordable tuition fees. This ensures that students from different socioeconomic backgrounds have access to higher education.

3.4 Promoting Sustainable Development:

Higher education institutions play an important role in addressing global challenges such as climate change and economic inequality. Studies show that education and green finance can promote sustainable energy development and environmental awareness.

3.5 Strengthening Economic Growth:

Universities contribute to economic development by producing skilled graduates who enter the workforce. Sustainable financing ensures that institutions continue to provide training and education needed for modern economies.

4. Sources of Sustainable Financing in Higher Education:

Higher education institutions rely on multiple funding sources to maintain financial sustainability.

4.1 Government Funding:

Government funding remains the primary source of financing for public universities in many countries. Governments provide grants, subsidies, and research funding to support education and national development goals.

Public funding helps maintain low tuition fees and ensures equal access to education. However, economic constraints and competing public priorities have reduced government spending in many regions.

4.2 Tuition Fees and Student Contributions:

Tuition fees are an important revenue source for universities. Students contribute to the cost of their education, helping institutions cover operational expenses.

Many institutions combine tuition fees with financial aid programs, scholarships, and student loan systems to ensure that education remains accessible.

4.3 Private Sector Partnerships:

Collaboration between universities and private companies has become increasingly common. Industries often fund research projects, provide scholarships, and invest in university programs related to their fields.

These partnerships benefit both parties. Universities receive financial support and practical knowledge, while companies gain access to skilled graduates and innovative research.

4.4 Donations and Philanthropy:

Philanthropic contributions from alumni, foundations, and private donors provide significant funding for universities. Donations are often used to support scholarships, research centers, and infrastructure development.

Endowment funds created through donations help institutions generate long-term financial stability.

4.5 International Funding and Grants:

International organizations and development agencies also provide financial support for education programs. These funds are often aimed at improving educational quality, research collaboration, and global knowledge exchange.

5. Sustainable Finance and Environmental Responsibility:

In recent years, sustainable financing has increasingly focused on environmental sustainability. Green finance initiatives encourage investments in projects that promote environmental protection and sustainable development.

Universities are integrating sustainability principles into their research and teaching programs. Higher education institutions play a crucial role in raising awareness about environmental challenges and developing innovative solutions for sustainable development.

For example, universities are investing in renewable energy research, green campus initiatives, and sustainable infrastructure. Financial support for these initiatives contributes to both environmental sustainability and institutional development.

6. Challenges in Sustainable Financing of Higher Education:

Despite its importance, achieving sustainable financing in higher education remains challenging.

6.1 Limited Public Funding:

Many governments face budget constraints, leading to reduced funding for universities. This creates financial pressure on institutions to find alternative funding sources.

6.2 Increasing Demand for Higher Education:

The number of students enrolling in universities continues to grow worldwide. This increases the need for infrastructure, faculty, and educational resources.

6.3 Rising Operational Costs:

Universities must invest in advanced technologies, research facilities, and digital learning systems. These investments significantly increase operational expenses.

6.4 Inequality in Access to Education:

High tuition fees and limited financial aid can restrict access to higher education for students from low-income backgrounds.

6.5 Economic and Political Instability:

Economic crises and political instability can disrupt funding sources and affect the long-term financial planning of educational institutions.

7. Strategies for Achieving Sustainable Financing:

To address these challenges, institutions and governments must adopt innovative strategies for sustainable financing.

7.1 Diversification of Funding Sources:

Universities should reduce dependence on a single funding source by combining government support, tuition fees, private investments, and international funding.

7.2 Public-Private Partnerships:

Collaboration between universities, industries, and government agencies can create new funding opportunities and promote innovation.

7.3 Efficient Financial Management:

Transparent budgeting, cost control, and performance-based funding systems can improve financial efficiency and accountability.

7.4 Technology and Digital Education:

Online learning platforms and digital resources can reduce operational costs while expanding access to education.

7.5 Scholarships and Financial Aid Programs:

Providing financial assistance ensures that students from diverse backgrounds can pursue higher education without financial barriers.

8. Future Perspectives:

The future of sustainable financing in higher education will depend on innovative policies, international cooperation, and effective financial management. Governments and institutions must work together to create financial systems that support long-term educational development.

New financial models such as impact investing, green bonds, and outcome-based funding may play an important role in supporting education systems. Additionally, technological advancements and digital education will create new opportunities for cost-effective learning.

Higher education institutions must also focus on sustainability in their operations, research, and community engagement. By integrating financial sustainability with social and environmental responsibility, universities can contribute to global development and create a more equitable education system.

9. Conclusion:

Sustainable financing is a critical factor in ensuring the long-term success of higher education institutions. As the demand for higher education continues to grow, universities must adopt innovative financial strategies that provide stable and diversified funding sources.

Government support, private investments, tuition fees, and international funding all play important roles in financing higher education. At the same time, institutions must implement efficient financial management practices to ensure transparency and accountability.

Despite various challenges such as limited public funding, rising costs, and increasing student demand, sustainable financing strategies can help universities maintain quality education, promote research and innovation, and expand access to education. By developing sustainable financial systems, higher education institutions can continue to contribute to economic development, social progress, and global sustainability.

References & Bibliography:

1. Azad, J. L. (2010). *Financing and management of higher education in India: The role of private sector.* New Delhi: Gyan Publishing House.
2. Panigrahi, J. (2022). *Higher education financing in India: Student loans and equity in access.* New York: Routledge.
3. Tilak, J. B. G. (2018). *Higher education, public good and markets.* London: Routledge.
4. Tilak, J. B. G. (2024). *Economics of engineering education in India: Growing challenges of access, excellence and equity.* New York: Routledge.

5. Varghese, N. V., & Panigrahi, J. (Eds.). (2019). *India higher education report 2018: Financing of higher education.* New Delhi: Sage Publications India.
6. John, J. (2013). *Education loan and inclusive growth: India in a comparative perspective.* Newcastle upon Tyne: Cambridge Scholars Publishing.
7. Tilak, J. B. G. (2018). *The writings of Jandhyala B. G. Tilak: Dilemmas in reforming higher education in India.* New Delhi: Sage Publications.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

RESEARCH AND INNOVATION FOR SUSTAINABILITY

Prof. Parate Santosh Shravana
Adv. M.N. Deshmukh Art's, Science and Commerce College, Rajur
Tal- Akole Dist- Ahilyanagar, 422604
Mob. No. 9762903465
Email- santoshparate25@gmail.com

Abstract:

Research and innovation play a vital role in promoting sustainability and addressing global challenges such as climate change, environmental degradation, and resource scarcity. Sustainable development requires new technologies, scientific knowledge, and innovative solutions that support economic growth while protecting the environment and promoting social well-being. Research helps generate knowledge about environmental issues, while innovation applies this knowledge to create practical solutions. Universities, research institutions, industries, and governments are increasingly focusing on sustainable research and innovation to achieve long-term development goals. This research paper examines the concept of research and innovation for sustainability, its importance, major areas of innovation, the role of educational institutions and governments, and the challenges faced in promoting sustainable research. The study highlights how research and innovation contribute to sustainable development and improve the quality of life for present and future generations.

1. Introduction:

In the modern world, societies face many environmental, economic, and social challenges. Issues such as climate change, pollution, loss of biodiversity, energy shortages, and population growth require urgent attention. Traditional methods of development are no longer sufficient to address these complex problems. Therefore, new knowledge and creative solutions are needed to achieve sustainable development.

Research and innovation are key drivers of sustainable development. Research refers to the systematic investigation and study of problems to discover new knowledge and solutions. Innovation refers to the process of applying new ideas, technologies, or methods to create improved products, services, or systems.

Together, research and innovation help societies develop sustainable technologies, improve resource management, and reduce environmental impacts. Governments, universities, and industries are increasingly investing in research and innovation to promote sustainability and achieve long-term economic growth.

In recent years, sustainable research and innovation have become global priorities. International organizations and governments are encouraging scientific research that supports environmental protection, renewable energy, sustainable agriculture, and responsible consumption.

2. Concept of Research and Innovation for Sustainability

Research and innovation for sustainability refer to the process of generating knowledge and developing solutions that support environmental protection, social well-being, and economic growth.

Sustainable research focuses on studying environmental challenges such as climate change, water scarcity, and biodiversity loss. It also examines social issues such as poverty, inequality, and access to resources. The goal is to understand these problems and identify effective strategies to address them.

Innovation, on the other hand, involves applying research findings to develop practical solutions. These solutions may include renewable energy technologies, sustainable agricultural practices, eco-friendly products, and smart urban systems.

Sustainability-focused research and innovation require collaboration among scientists, policymakers, industries, and communities. By working together, these groups can develop solutions that balance economic development with environmental protection.

3. Importance of Research and Innovation for Sustainability:

3.1 Solving Environmental Problems:

Research helps scientists understand environmental issues such as climate change, pollution, and deforestation. Through innovation, new technologies can be developed to reduce pollution, conserve natural resources, and protect ecosystems.

3.2 Promoting Renewable Energy:

One of the most important areas of sustainable innovation is renewable energy. Research has led to the development of solar power, wind energy, and other clean energy technologies that reduce dependence on fossil fuels.

3.3 Improving Resource Management:

Research and innovation help improve the management of natural resources such as water, forests, and minerals. Sustainable resource management ensures that resources are used efficiently without harming future generations.

3.4 Supporting Economic Growth:

Innovation contributes to economic development by creating new industries, products, and job opportunities. Sustainable technologies also help industries reduce costs and increase efficiency.

3.5 Enhancing Quality of Life:

Research and innovation improve living conditions by developing better healthcare systems, sustainable housing, and efficient transportation systems.

4. Key Areas of Sustainable Research and Innovation:

4.1 Renewable Energy Technologies:

Research in renewable energy has led to significant advancements in solar, wind, hydro, and geothermal energy systems. These technologies provide clean energy solutions that reduce greenhouse gas emissions.

4.2 Sustainable Agriculture:

Agricultural research focuses on developing sustainable farming practices that increase food production while protecting soil, water, and biodiversity. Innovations such as organic farming, precision agriculture, and drought-resistant crops support sustainable food systems.

4.3 Green Technology:

Green technologies are designed to reduce environmental impacts and promote resource efficiency. Examples include energy-efficient appliances, electric vehicles, and waste recycling systems.

4.4 Water Management:

Research on water conservation and management helps address issues such as water scarcity and pollution. Technologies such as rainwater harvesting, wastewater treatment, and desalination contribute to sustainable water use.

4.5 Sustainable Urban Development:

Rapid urbanization has created challenges such as pollution, waste management, and energy consumption. Research and innovation support the development of smart cities, green buildings, and sustainable transportation systems.

5. Role of Educational Institutions in Sustainable Research and Innovation:

Educational institutions play a crucial role in promoting research and innovation for sustainability.

5.1 Conducting Research:

Universities and research centers conduct studies on environmental protection, renewable energy, and sustainable development.

5.2 Developing New Technologies:

Through research laboratories and innovation centers, universities develop technologies that address sustainability challenges.

5.3 Training Future Researchers:

Higher education institutions prepare students with the knowledge and skills needed to conduct research and develop innovative solutions.

5.4 Collaboration with Industries:

Universities often collaborate with industries to develop sustainable technologies and bring innovations to the market.

5.5 Promoting Sustainable Practices:

Educational institutions can implement eco-friendly campus initiatives such as energy conservation, waste management, and green infrastructure.

6. Role of Government and Industry:

Governments and industries also play important roles in promoting research and innovation for sustainability.

6.1 Government Policies and Funding:

Governments support research through funding programs, policies, and national research institutions. These initiatives encourage scientists and researchers to focus on sustainability-related projects.

6.2 Industrial Innovation:

Industries invest in research and development to create sustainable products and technologies. Many companies are now adopting environmentally friendly practices and investing in green innovations.

6.3 Public-Private Partnerships:

Collaboration between governments, universities, and industries can accelerate sustainable innovation. Public-private partnerships help share resources, knowledge, and expertise.

7. Challenges in Promoting Research and Innovation for Sustainability:

Despite its importance, several challenges affect sustainable research and innovation.

Limited Funding: Many research institutions lack sufficient financial resources to conduct large-scale sustainability research.

Lack of Collaboration: Effective innovation requires collaboration among scientists, industries, and policymakers, which may not always occur.

Technological Barriers: Developing sustainable technologies often requires advanced knowledge and expensive equipment.

Policy Limitations: In some countries, weak environmental policies may slow down the adoption of sustainable innovations.

Public Awareness: Lack of awareness about sustainability may reduce support for research initiatives.

8. Strategies to Promote Sustainable Research and Innovation:

To overcome these challenges, several strategies can be adopted.

Increase Research Funding: Governments and private organizations should invest more in sustainability-related research.

Encourage Interdisciplinary Research: Collaboration between different scientific fields can lead to more effective solutions.

Strengthen International Cooperation: Global collaboration allows researchers to share knowledge and resources.

Promote Innovation Ecosystems: Creating research parks, incubators, and innovation hubs can support sustainable technology development.

Enhance Education and Training: Training programs can prepare researchers and professionals to address sustainability challenges.

9. Future Perspectives:

The future of sustainability depends heavily on research and innovation. As environmental challenges continue to grow, scientists and innovators must develop new technologies and solutions that support sustainable development.

Advances in artificial intelligence, biotechnology, renewable energy, and environmental science are expected to play a major role in addressing sustainability challenges. Governments, universities, and industries must work together to create supportive environments for research and innovation.

Sustainable innovation will not only help protect the environment but also create new economic opportunities and improve the quality of life worldwide.

10. Conclusion:

Research and innovation are essential for achieving sustainable development and addressing global challenges. Through scientific research, societies gain a deeper understanding of environmental and social issues. Innovation transforms this knowledge into practical solutions that support sustainable development.

Key areas such as renewable energy, sustainable agriculture, water management, and green technology demonstrate how research and innovation contribute to environmental protection and economic growth.

Educational institutions, governments, and industries must collaborate to promote sustainable research and innovation. By investing in knowledge, technology, and education, societies can develop effective solutions that ensure a sustainable future for present and future generations.

References:

1. Sinha, A. K., Mohapatra, A. K., Pandey, A., & Utkarsh. (2016). *Innovation and sustainable development.* New Delhi: Bloomsbury India.
2. Bedamatta, R., Laishram, B., & Johari, S. (Eds.). (2024). *Research and innovation for sustainable development goals.* Singapore: Springer.
3. Dutta, V., & Ghosh, P. (Eds.). (2023). *Sustainability: Science, policy, and practice in India – Challenges and opportunities.* Cham: Springer.
4. Singh, S., Jha, J., Indira, A., & Arunkumar, A. V. (Eds.). (2025). *Institutions and public policy for India's sustainable development: Perspectives on governance, technology and finance.* New Delhi: Routledge India.
5. Raina, R. S. (Ed.). (2015). *Science, technology and development in India.* Hyderabad: Orient Blackswan.
6. Raina, R. S., & Das, K. (Eds.). (2020). *Inclusive innovation: Evidence and options in rural India.* Singapore: Springer.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

ROLE OF INDIAN HIGHER EDUCATION IN ACHIEVING SUSTAINABLE DEVELOPMENT GOALS

Mr. Ganesh S. Kusmude
Dept.of English
Adv. M. N. Deshmukh Arts, Science and Commerce College, Rajur
Tal-Akole Dist- Ahilyanagar 422 604
Mob-9923984797
E-mail: kusmudegs7@gmail.com

Abstract:

Education plays an important role in the life of man. Education can change the entire life of ones. Education is called as the third eye of human being. Man is nothing in his life without education. So, one must have good education, knowledge and skills for better life. Man has no value in the society without education. We can say that, education is the real ornament of human beings. Society welcome and respect the knowledgeable person. Education means an enlightening experience. Education is the process of receiving or giving systematic instruction, especially all school,college or university Education reveals mans inner strength. Education makes a man into human being. Education is both the act of teaching knowledge to others and the act of receiving knowledge from someone else.The word 'education' has been derived from the latin word-'educare',-its means to train or to mold. And second root word is "educere" it's meaning is to lead out. Bharatratan Dr. B.R. Ambedkar has said about education-"Education is the birth right of every person and this right cannot be denied to anyone. Education is what makes a person fearless, teaches him the lesson of unity , makes him aware of his rights and inspires him to struggle for his rights". This paper examines the multifaceted role of Indian Higher Education Institutions (HEIs) in advancing the 17 Sustainable Development Goals (SDGs). By analyzing the alignment of the National Education Policy (NEP) 2020 with the 2030 Agenda, the research highlights how Indian universities are integrating sustainability into curricula, research, and campus operations. Despite significant progress in SDG 4 (Quality Education) and SDG 5 (Gender Equality), challenges such as funding gaps and rural-urban disparities remain.

Keywords: higher education, SDG, enlightening, educere, knowledge, rights

Introduction:

The 2030 Agenda for Sustainable Development, adopted by all UN Member States in 2015, provides a shared blueprint for peace and prosperity. India, home to one of the world's largest higher education systems, is central to this global mission. HEIs are uniquely positioned to address these goals through four key pillars:

 Education: Shaping the values and skills of future leaders.

 Research: Generating local solutions for global problems (e.g., climate change, poverty).

 Operations: Modeling sustainable practices within "campus townships."

 Advocacy: Influencing public policy and community engagement.

2. Policy Framework: The Impact of NEP 2020

The National Education Policy (NEP) 2020 serves as the primary driver for SDG alignment in India. It mirrors several SDG targets:

- **SDG 4 (Quality Education):** Through the **Academic Bank of Credits (ABC)** and multidisciplinary learning, NEP 2020 promotes lifelong learning and flexible pathways.
- **SDG 5 & 10 (Equality):** The creation of **Special Education Zones (SEZs)** for socio-economically disadvantaged groups addresses equity and inclusion.
- **SDG 8 (Decent Work):** Integration of vocational education from the undergraduate level aims to bridge the "employability gap."

3. Strategic Dimensions of Implementation

A. Curricular Integration

Recent data from NAAC (National Assessment and Accreditation Council) suggests that approximately **74% of Indian HEIs** have integrated cross-cutting issues like professional ethics, gender, and environmental sustainability into their core curricula. Mandatory environmental studies at the undergraduate level have raised ecological consciousness among millions of students.

B. Research and Innovation

Indian universities are increasingly prioritizing interdisciplinary research. The establishment of **Multidisciplinary Education and Research Universities (MERUs)** has fostered innovation in:

- **Renewable Energy (SDG 7):** Solar and green hydrogen research.
- **Clean Water (SDG 6):** Low-cost filtration and water management technologies.
- **Sustainable Cities (SDG 11):** Smart-campus initiatives and urban planning.

C. Institutional Leadership & Community Outreach

The Association of Indian Universities (AIU) has spearheaded the "Realizing SDGs through HEIs" campaign. Many institutions now adopt local villages (Unnat Bharat Abhiyan), applying academic knowledge to solve rural challenges in sanitation, digital literacy, and agriculture.

4. Progress Status (2025-2026)

According to the **Sustainable Development Report 2025**, India has entered the top 100 countries in the SDG Index (ranked 99th), largely due to improvements in education access and poverty reduction.

SDG Goal	Progress in Indian HEIs
SDG 4: Quality Education	Significant increase in Gross Enrolment Ratio (GER) and digital infrastructure (DIKSHA, SWAYAM).
SDG 5: Gender Equality	Higher female representation in STEM fields and leadership roles.
SDG 13: Climate Action	Rapid adoption of net-zero campus targets and green audits.

Conclusion:

Indian Higher Education is no longer a peripheral player but a central engine for the SDGs. By 2030, the success of India's sustainability agenda will depend on how effectively HEIs can translate policy (NEP 2020) into grassroots action. Moving forward, a stronger focus on "Actionable Research" and increased public-private partnerships will be vital.

References:

1. NITI Aayog (2025). SDG India Index & Dashboards 2024-25.
2. Ministry of Education (2020). National Education Policy 2020.
3. Association of Indian Universities (2024). Building a Sustainable Future: Realizing SDGs through HEIs.
4. UN Sustainable Development Solutions Network (2025). 10th Sustainable Development Report.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

GLOBALIZATION AND KNOWLEDGE SHARING

Prof. Dr. Sonawane Rajaram Ramdas
(Head- Department of History)
Adv. M. N. Deshmukh Arts, Science & Commerce College Rajur,
Tal.- Akole, Dist.- Ahilyanagar, Pin.- 422604.
Mobile No. 9767333391
Email- sonawanerajaram123@gmail.com

Abstract-

Globalization has significantly reshaped the way knowledge is created, shared, and utilized across the world. With the rapid advancement of information and communication technologies, knowledge can now move across borders faster than ever before. Knowledge sharing has become an essential factor in economic development, innovation, and organizational competitiveness. Global networks of trade, multinational corporations, digital platforms, and academic collaborations facilitate the exchange of knowledge among individuals, institutions, and nations. However, despite its advantages, globalization also introduces challenges such as intellectual property concerns, cultural differences, and the digital divide. This research paper examines the relationship between globalization and knowledge sharing, explores the mechanisms through which knowledge is transferred globally, discusses the benefits and challenges associated with knowledge sharing, and analyzes the role of technology in shaping global knowledge exchange.

1. Introduction-

Globalization refers to the increasing integration and interconnectedness of countries through trade, investment, communication, technology, and cultural exchange. Over the past few decades, globalization has accelerated due to advances in transportation and information technology, making it easier for people, goods, and ideas to move across national borders. One of the most important aspects of globalization is the rapid spread of knowledge and information.

Knowledge sharing involves the exchange of information, skills, and expertise between individuals, organizations, and societies. In a globalized world, knowledge sharing plays a crucial role in promoting innovation, improving productivity, and enhancing collaboration across borders. Modern economies increasingly rely on knowledge-based industries where information and innovation are key drivers of growth.

Globalization has transformed traditional knowledge systems by enabling new forms of collaboration between universities, businesses, governments, and international organizations. Through digital communication technologies, global trade networks, and international research collaborations, knowledge can be generated and disseminated worldwide. However, the process of knowledge sharing is not always straightforward, as

various social, economic, and technological factors influence how knowledge is distributed and utilized.

This paper explores how globalization influences knowledge sharing and examines the opportunities and challenges associated with global knowledge exchange.

2. Concept of Globalization-

Globalization is a multidimensional process that involves economic, political, cultural, and technological integration among nations. Economically, globalization refers to the expansion of international trade, foreign direct investment, and multinational corporations operating across different countries. Politically, it involves increased cooperation between governments and international institutions. Culturally, globalization promotes the exchange of ideas, values, and traditions among different societies.

Technological advancement has been one of the major drivers of globalization. The development of the internet, mobile communication, and digital platforms has enabled people to access information instantly from anywhere in the world. As a result, globalization has created a global knowledge economy where ideas and information circulate rapidly.

The concept of globalization also includes the development of global networks of collaboration. Universities and research institutions now collaborate on international projects, businesses share expertise across global markets, and governments cooperate to address global challenges such as climate change, health crises, and economic development.

3. Understanding Knowledge and Knowledge Sharing-

Knowledge can be defined as information, skills, and understanding gained through education, experience, or research. Scholars often categorize knowledge into two main types:

3.1 Explicit Knowledge-

Explicit knowledge refers to knowledge that can be easily documented, stored, and transmitted in written or digital form. Examples include textbooks, research papers, manuals, and databases.

3.2 Tacit Knowledge-

Tacit knowledge refers to personal knowledge that is difficult to formalize or communicate. It includes experience, intuition, and skills developed through practice. Tacit knowledge is often transferred through direct interaction, training, and collaboration.

Knowledge sharing is the process of exchanging both explicit and tacit knowledge between individuals or groups. In organizations and institutions, knowledge sharing helps improve efficiency, problem-solving, and innovation.

In the context of globalization, knowledge sharing occurs across national boundaries through various channels such as international trade, digital communication, and academic collaboration.

4. Globalization and the Flow of Knowledge-

Globalization has greatly increased the speed and scale of knowledge exchange. In the past, knowledge transfer between countries was limited due to geographical and technological barriers. Today, digital technologies and global networks allow knowledge to be shared instantly across continents.

Global knowledge flows occur through several important mechanisms.

4.1 International Trade-

International trade allows countries to access new technologies, products, and production methods. When countries import goods and services from other nations, they also gain access to the knowledge embedded in those products. For example, developing countries often adopt advanced technologies from developed nations through trade.

Trade also encourages learning and innovation. Companies exposed to international competition must continuously improve their products and processes, which encourages knowledge sharing within and between organizations.

4.2 Multinational Corporations-

Multinational corporations (MNCs) play a major role in global knowledge transfer. These companies operate in multiple countries and facilitate the exchange of knowledge between headquarters and subsidiaries.

For example, multinational firms share management techniques, production technologies, and research findings with their branches in different countries. Employees working in multinational companies often gain exposure to global practices and expertise.

MNCs also contribute to local economic development by training workers, introducing new technologies, and collaborating with local firms and universities.

4.3 International Education and Research Collaboration-

Universities and research institutions play a crucial role in global knowledge sharing. International collaboration among scientists and researchers has increased significantly in recent years.

Academic conferences, research partnerships, and exchange programs allow scholars from different countries to share knowledge and develop innovative solutions to global problems. Many universities also offer joint research projects and international degree programs that promote knowledge exchange.

Scientific publications and open-access journals further contribute to global knowledge dissemination by making research findings accessible to scholars worldwide.

4.4 Digital Technologies and the Internet-

The internet has revolutionized knowledge sharing by enabling instant access to information. Online platforms, digital libraries, and educational websites allow people to learn and collaborate regardless of their location.

Technologies such as cloud computing, social media, and collaborative software enable organizations and individuals to share knowledge efficiently. Online learning platforms, webinars, and virtual conferences have also become important tools for global knowledge exchange.

5. Importance of Knowledge Sharing in a Globalized World-

Knowledge sharing is a key factor in the development of modern economies and organizations. Several important benefits arise from global knowledge exchange.

5.1 Innovation and Technological Development-

Innovation often occurs when individuals from different backgrounds share ideas and perspectives. Global knowledge exchange encourages creativity and helps develop new technologies and solutions.

Many technological advancements result from international collaboration between scientists, engineers, and researchers.

5.2 Economic Growth and Development-

Access to global knowledge allows countries to improve their productivity and competitiveness. Developing countries can learn from the experiences of advanced economies and adopt modern technologies to accelerate development.

Knowledge sharing also helps businesses expand into international markets and improve their products and services.

5.3 Organizational Learning and Competitiveness-

Organizations that encourage knowledge sharing among employees are more likely to innovate and adapt to changing market conditions. Global companies benefit from knowledge sharing by leveraging expertise from different regions and cultures.

For example, companies may use global teams to develop products that meet the needs of diverse markets.

5.4 Development of Knowledge Economies-

In today's world, knowledge has become one of the most valuable economic resources. Countries that invest in education, research, and innovation can build strong knowledge economies.

Knowledge sharing plays a critical role in developing skilled workforces, fostering innovation, and improving economic performance.

6. Challenges of Global Knowledge Sharing-

Despite its benefits, global knowledge sharing also faces several challenges.

6.1 Cultural and Language Barriers-

Differences in language, communication styles, and cultural values can create misunderstandings and limit effective knowledge exchange. Organizations operating internationally must develop strategies to overcome these barriers.

6.2 Intellectual Property Protection-

Intellectual property rights protect inventions, designs, and creative works. However, concerns about intellectual property theft may discourage individuals and organizations from sharing knowledge freely.

Balancing knowledge sharing with intellectual property protection remains an important challenge.

6.3 Digital Divide-

Not all countries have equal access to digital technologies and internet infrastructure. The digital divide creates inequalities in access to information and opportunities for knowledge sharing.

Many developing countries face challenges such as limited internet connectivity, lack of technological resources, and insufficient digital literacy.

6.4 Unequal Distribution of Knowledge-

Most research and innovation activities are concentrated in developed countries. As a result, developing countries may have limited participation in global knowledge production.

Addressing this imbalance requires increased investment in education, research infrastructure, and international collaboration.

7. Role of Technology in Knowledge Sharing-

Technology plays a crucial role in facilitating knowledge sharing in the globalized world. Digital communication tools allow people to collaborate across geographical boundaries.

Some important technologies that support knowledge sharing include:

- Cloud computing platforms
- Online collaboration tools
- Digital libraries and research databases
- Artificial intelligence and data analytics
- Social media and professional networking platforms

These technologies enable organizations and individuals to create, store, and distribute knowledge more efficiently than ever before.

Artificial intelligence and big data analytics are also transforming knowledge management by enabling organizations to analyze large amounts of information and generate valuable insights.

8. Future Trends in Global Knowledge Sharing-

The future of knowledge sharing will likely be influenced by several emerging trends. First, artificial intelligence will play a major role in organizing and analyzing global knowledge resources. AI-powered systems can help researchers discover new patterns and insights from large datasets.

Second, open innovation and collaborative research will become more common. Organizations will increasingly collaborate with external partners to develop new technologies and solutions.

Third, digital learning platforms will expand access to education and knowledge worldwide. Online courses and virtual learning environments will allow people to acquire new skills regardless of their location.

Finally, global challenges such as climate change, pandemics, and sustainable development will require increased international cooperation and knowledge sharing.

9. Conclusion-

Globalization has transformed the way knowledge is produced, shared, and applied across the world. Through international trade, multinational corporations, academic collaborations, and digital technologies, knowledge now flows across borders more rapidly than ever before.

Knowledge sharing plays a vital role in promoting innovation, economic growth, and organizational competitiveness. Countries and organizations that actively participate in global knowledge networks can benefit from new ideas, technologies, and opportunities.

However, challenges such as cultural barriers, intellectual property concerns, and the digital divide must be addressed to ensure equitable access to knowledge. Governments, institutions, and businesses must work together to create policies and infrastructures that support open and effective knowledge sharing.

As globalization continues to evolve, knowledge sharing will remain a critical factor in addressing global challenges and advancing human development.

References-

1. Ikujiro Nonaka, and Hirotaka Takeuchi. *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*. Oxford UP, 1995.
2. Manuel Castells. *The Rise of the Network Society*. 2nd ed., Wiley-Blackwell, 2010.
3. Thomas L. Friedman. *The World Is Flat: A Brief History of the Twenty-First Century*. Farrar, Straus and Giroux, 2005.
4. Peter F. Drucker. *Post-Capitalist Society*. HarperBusiness, 1993.
5. Henry Chesbrough. *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Harvard Business School Press, 2003.
6. World Bank. *World Development Report: Knowledge for Development*. World Bank Publications, 2020.

7. Organisation for Economic Co-operation and Development. *Knowledge Flows in the Global Economy*. OECD Publishing, 2019.
8. Paul Romer. "Endogenous Technological Change." *Journal of Political Economy*, vol. 98, no. 5, 1990, pp. S71–S102.
9. International Monetary Fund. "Globalization Helps Spread Knowledge and Technology Across Borders." IMF, 2018.
10. United Nations Educational, Scientific and Cultural Organization. *Global Education Monitoring Report*. UNESCO Publishing, 2021.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

EDUCATION FOR SUSTAINABLE DEVELOPMENT: BUILDING KNOWLEDGE FOR A SUSTAINABLE FUTURE

Mr. Tambe Yogesh Bapusaheb
Assistant Professor
MES, Arts, Commerce & Science College, Sonai
Tal:- Newasa, Dist:- Ahilyanagar
Mob-9665040250
E- Mail- yatmbe.1991@gmail.com

Abstract

Education plays a crucial role in addressing global challenges such as climate change, poverty, inequality, and environmental degradation. Education for Sustainable Development (ESD) is an educational approach that equips learners with the knowledge, skills, values, and attitudes necessary to create a sustainable society. International organizations such as the United Nations and UNESCO promote ESD as a key strategy to achieve the global sustainability agenda. This research paper explores the concept of education for sustainable development, its importance, principles, and implementation in educational institutions. The study also discusses the challenges and strategies for integrating sustainability into education systems. The findings indicate that integrating sustainability into education can promote environmental awareness, social responsibility, and economic sustainability, helping societies move toward a more balanced and sustainable future.

1. Introduction

Sustainable development has become a major global concern in the twenty-first century. Rapid industrialization, population growth, and environmental degradation have created serious challenges that threaten the well-being of present and future generations. To address these issues, education has been recognized as one of the most powerful tools for promoting sustainable practices and responsible decision-making.

Education for Sustainable Development (ESD) focuses on integrating sustainability concepts into educational systems so that individuals can develop the knowledge and skills required to address complex global problems. According to UNESCO, ESD empowers individuals to make informed decisions and take responsible actions that benefit the environment, society, and the economy.

The international community has also emphasized the importance of education in the global sustainability agenda. The United Nations included education as a key component of the **2030 Agenda for Sustainable Development**, particularly through the United Nations Sustainable Development Goals (SDGs). Goal 4 focuses on ensuring inclusive and quality education while promoting lifelong learning opportunities for all.

This research paper examines the concept of education for sustainable development, its principles, its role in achieving sustainability, and the challenges associated with its implementation.

2. Concept of Sustainable Development

The concept of sustainable development refers to development that meets current needs without compromising the ability of future generations to meet their own needs. Sustainable development aims to balance economic growth, social well-being, and environmental protection.

Sustainable development is based on three main pillars:

2.1 Environmental Sustainability

green sustainability focuses on protecting natural resources, ecosystems, and biodiversity. It involves reducing pollution, conserving energy, and promoting responsible use of natural resources.

2.2 Economic Sustainability

Economic sustainability refers to economic growth that does not harm environmental or social systems. It encourages responsible production, sustainable industries, and efficient resource management.

2.3 Social Sustainability

Social sustainability focuses on improving quality of life, promoting equality, ensuring access to education, and protecting human rights.

Education plays an essential role in promoting these three pillars because it develops awareness, knowledge, and values that support sustainable lifestyles.

3. Concept of Education for Sustainable Development

Education for Sustainable Development is an educational approach that aims to prepare individuals to contribute to sustainable societies. It integrates sustainability issues such as climate change, poverty, biodiversity, and resource management into teaching and learning processes.

According to UNESCO, ESD equips learners with the knowledge, skills, attitudes, and values necessary to address sustainability challenges and make responsible decisions.

ESD also promotes critical thinking, problem-solving abilities, and active participation in society. It encourages learners to understand the interconnected nature of environmental, economic, and social issues.

Another important aspect of ESD is lifelong learning. Sustainable education does not only occur in schools and universities but also through community programs, public awareness initiatives, and informal education systems.

4. Objectives of Education for Sustainable Development

Education for Sustainable Development aims to achieve several key objectives:

4.1 Promoting Environmental Awareness

ESD helps students understand environmental challenges such as climate change, deforestation, and pollution. Through education, individuals become aware of the importance of protecting natural resources.

4.2 Developing Critical Thinking Skills

Sustainability issues are complex and interconnected. Education encourages students to analyze problems, evaluate solutions, and make informed decisions.

4.3 Encouraging Responsible Behavior

ESD promotes responsible lifestyles such as energy conservation, recycling, and sustainable consumption.

4.4 Promoting Social Responsibility

Education fosters values such as equality, respect for cultural diversity, and community participation.

4.5 Supporting Sustainable Economic Development

Education also contributes to developing skills necessary for sustainable industries and green economies.

5. Importance of Education for Sustainable Development

Education for sustainable development is essential for building a sustainable future.

5.1 Addressing Environmental Challenges

Environmental problems such as climate change and biodiversity loss require informed and responsible actions. Education provides knowledge about these issues and encourages sustainable practices.

5.2 Reducing Poverty

Education helps people acquire skills that improve employment opportunities and economic stability.

5.3 Promoting Social Equality

Access to education reduces social inequalities and empowers marginalized communities.

5.4 Encouraging Innovation

Education encourages scientific research and technological innovation, which can provide solutions to sustainability challenges.

5.5 Supporting Global Citizenship

ESD promotes global awareness and encourages individuals to take responsibility for protecting the planet.

6. Implementation of Education for Sustainable Development

Implementing ESD requires changes in educational systems, policies, and teaching methods.

6.1 Curriculum Integration

Sustainability topics should be integrated into school and university curricula across subjects such as science, economics, geography, and social studies.

6.2 Teacher Training

Teachers must be trained to effectively teach sustainability concepts and encourage participatory learning methods.

6.3 Sustainable Learning Environments

Educational institutions should adopt sustainable practices such as energy conservation, waste reduction, and green campus initiatives.

6.4 Community Participation

Schools and universities should collaborate with local communities to promote sustainability initiatives.

6.5 Government Policies

Governments must develop policies that support sustainability education and allocate resources for its implementation.

7. Challenges in Implementing Education for Sustainable Development

Despite its importance, several challenges hinder the effective implementation of ESD.

7.1 Lack of Awareness

Many educators and policymakers are not fully aware of the importance of sustainability education.

7.2 Limited Resources

Developing countries often face financial and infrastructure limitations that affect education systems.

7.3 Inadequate Teacher Training

Teachers may lack the necessary knowledge and training to teach sustainability topics effectively.

7.4 Curriculum Constraints

Traditional curricula often focus on theoretical knowledge rather than interdisciplinary learning.

7.5 Policy Gaps

In some countries, educational policies do not fully integrate sustainability principles.

8. Strategies for Promoting Education for Sustainable Development

To overcome these challenges, several strategies can be adopted:

1. Integrating sustainability into national education policies
2. Providing teacher training programs on sustainability education
3. Encouraging interdisciplinary learning
4. Promoting research and innovation in sustainability
5. Encouraging youth participation in environmental initiatives
6. Strengthening partnerships between governments, universities, and communities

9. Conclusion

Education for Sustainable Development is essential for addressing the global challenges facing humanity today. By integrating sustainability concepts into education systems, individuals can develop the knowledge, skills, and values required to build a sustainable society. International organizations such as the UNESCO emphasize the importance of sustainability education in achieving the global development agenda. Education empowers individuals to make responsible decisions, adopt sustainable lifestyles, and contribute to environmental protection, social equality, and economic stability. Therefore, governments, educators, and institutions must work together to promote education for sustainable development and ensure a better future for coming generations.

References (Example)

1. UNESCO Education for Sustainable Development.
2. United Nations. Sustainable Development Goals (SDGs).
3. UNESCO (2024). Education for Sustainable Development Framework.
4. Global Education Monitoring Report.
5. Sustainable Development Agenda 2030.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

CHALLENGES AND OPPORTUNITIES OF SUSTAINABLE FINANCING IN HIGHER EDUCATION

Mr. Nitin Baban Shende
Assistant Professor
Dept of Commerce
Mula Education Societies,
Arts, Commerce & Science College, Sonai
Mobile no:- 9370679137
E-Mail- shendenitin9898@gmail.com

Abstract:

Sustainable financing has become an essential component for the long-term development of higher education institutions across the world. Universities and colleges require stable financial resources to maintain quality education, improve infrastructure, support research activities, and ensure accessibility for students. However, many institutions face financial constraints due to increasing operational costs, limited government funding, and growing student enrollment. Sustainable financing aims to address these challenges by promoting diversified funding sources, efficient resource management, and innovative financial strategies.This study examines the challenges and opportunities associated with sustainable financing in higher education. The research highlights issues such as dependency on government grants, rising tuition fees, unequal distribution of resources, and limited private investment. At the same time, it explores opportunities including public-private partnerships, international collaborations, alumni contributions, research funding, and digital education models that can support sustainable financial systems.The study adopts a descriptive research methodology based on secondary data collected from research articles, reports, and educational policy documents. The findings suggest that adopting diversified financial strategies and effective policy frameworks can significantly improve financial sustainability in higher education institutions. Sustainable financing is therefore essential for ensuring quality education, institutional stability, and long-term growth in the global higher education sector.

Key Words: Sustainable Financing,Higher Education, Financial Sustainability, Educational Funding, Public-Private Partnership.

Introduction:

Higher education plays a crucial role in the social, economic, and technological development of any nation. Universities and colleges are responsible for producing skilled human resources, promoting innovation, and contributing to national development. However, maintaining quality higher education requires significant financial resources. Over the years, the demand for higher education has increased rapidly due to population growth, globalization,

and the need for advanced skills. As a result, the financial burden on higher education institutions has also increased.Traditionally, higher education institutions have relied heavily on government funding to meet their financial needs. Governments provide grants, subsidies, and policy support to universities and colleges. However, in many countries, public funding for higher education has not increased at the same rate as student enrolment and institutional expansion. This has created financial challenges for many institutions, making it difficult to maintain infrastructure, provide quality teaching, and support research activities.Sustainable financing has emerged as an important solution to address these financial challenges. Sustainable financing refers to the development of long-term financial strategies that ensure stable and adequate funding for higher education institutions. It involves the diversification of funding sources, including government support, tuition fees, private investment, research grants, donations, and partnerships with industries. By adopting sustainable financing models, institutions can reduce their dependence on a single source of funding and ensure financial stability.

Despite its importance, implementing sustainable financing in higher education is not without challenges. Many institutions face difficulties in attracting private investment, managing financial resources effectively, and balancing affordability with financial sustainability. Increasing tuition fees may help institutions generate revenue, but it can also limit access to education for students from economically weaker backgrounds.At the same time, several opportunities exist to improve sustainable financing in higher education. Public-private partnerships, international collaborations, alumni contributions, and digital learning platforms can provide additional financial resources for institutions. Governments and policymakers are also exploring innovative funding mechanisms to ensure long-term sustainability in higher education.

Therefore, it is important to examine both the challenges and opportunities associated with sustainable financing in higher education. Understanding these factors can help policymakers, educational administrators, and stakeholders develop effective financial strategies that support the growth and development of higher education institutions while ensuring accessibility and quality education for students.

Objectives of the Study:

1. To understand the concept of sustainable financing in higher education.
2. To identify the major challenges faced in financing higher education.
3. To examine opportunities for improving sustainable financing systems.
4. To analyse the role of government and private sector in educational funding.
5. To suggest strategies for improving financial sustainability in higher education institutions.

Research Methodology:

This study is based on a **descriptive research design**. The research relies primarily on **secondary data sources** such as research journals, government reports, educational policy documents, books, and online academic databases. The collected data were analyzed using qualitative and simple statistical methods to understand the financial challenges and opportunities in higher education. Tables and descriptive interpretation have been used to present the data clearly.

Review of Literature:

Previous studies highlight the growing importance of sustainable financing in higher education systems worldwide. According to Johnstone (2010), increasing student enrollment and limited public funding have created financial pressure on universities, requiring institutions to adopt diversified funding strategies. Salmi (2017) emphasized that sustainable financing is essential for maintaining quality education and supporting research activities in universities.

Altbach and Salmi (2011) noted that higher education institutions must develop innovative financial models, including partnerships with industries and international collaborations, to ensure long-term financial sustainability. Similarly, Tilak (2015) argued that excessive reliance on tuition fees can lead to inequality in access to education, particularly for students from disadvantaged backgrounds.

UNESCO (2015) highlighted that governments should develop balanced funding policies that combine public investment with private contributions. Jongbloed (2004) suggested that diversified funding sources, including alumni donations and research grants, can significantly improve financial sustainability.

Overall, existing literature indicates that sustainable financing requires effective policy frameworks, financial diversification, and efficient management practices. These strategies can help higher education institutions address financial challenges while maintaining quality and accessibility.

Importance of the Study:

Sustainable financing is essential for the long-term stability and development of higher education institutions. This study is important because it helps to understand how financial resources can be managed effectively to support quality education and institutional growth. Many universities and colleges face financial difficulties due to increasing operational costs, limited government funding, and rising student enrolment. By examining the challenges and opportunities of sustainable financing, this research provides insights into how institutions can overcome these financial barriers.

The study is also significant for policymakers and educational administrators who are responsible for developing financial strategies for higher education. Understanding sustainable financing models can help them design policies that ensure equitable access to education while maintaining financial stability. In addition, the study highlights the importance of diversified

funding sources such as public-private partnerships, research funding, and alumni contributions.

Furthermore, this research contributes to academic discussions on educational financing by providing a comprehensive overview of financial sustainability in higher education. The findings of the study can help institutions adopt innovative financial practices and improve resource management. Ultimately, sustainable financing can support the development of a strong higher education system that promotes research, innovation, and social development.

Table 1: Sources of Funding in Higher Education

Source	Percentage
Government Funding	45%
Tuition Fees	30%
Private Investment	15%
Donations & Grants	10%

The table shows the major sources of funding for higher education institutions. Government funding contributes the largest share with 45 percent, indicating that public investment remains the primary financial support for universities and colleges. Tuition fees account for 30 percent of the total funding, reflecting the increasing reliance on student contributions. Private investment represents 15 percent, showing the growing involvement of industries and private organizations in supporting education. Donations and grants contribute 10 percent, which includes support from alumni, philanthropic organizations, and research foundations. The data highlights the need for diversified funding sources to ensure financial sustainability.

Table 2: Major Financial Challenges

Challenge	Percentage
Insufficient Government Funding	35%
Rising Operational Costs	25%
Increasing Student Enrollment	20%
Limited Private Investment	20%

This table illustrates the major financial challenges faced by higher education institutions. Insufficient government funding is identified as the most significant challenge, accounting for 35 percent. Many institutions struggle to maintain quality education due to limited financial support from public sources. Rising operational costs, including infrastructure

maintenance, technology, and staff salaries, represent 25 percent of the challenges. Increasing student enrollment creates additional pressure on institutional resources, contributing to 20 percent of the challenges. Limited private investment also accounts for 20 percent, indicating the need for stronger collaboration between educational institutions and the private sector to ensure sustainable financial support.

Table 3: Opportunities for Sustainable Financing

Opportunity	Percentage
Public-Private Partnerships	30%
Research Funding	25%
Alumni Contributions	20%
International Collaboration	25%

The table highlights potential opportunities for improving sustainable financing in higher education. Public-private partnerships represent the largest opportunity with 30 percent, demonstrating the importance of collaboration between educational institutions and industries. Research funding accounts for 25 percent and plays a significant role in supporting innovation and academic development. International collaboration also contributes 25 percent by providing access to global funding opportunities and academic exchange programs. Alumni contributions represent 20 percent, indicating the growing role of former students in supporting their institutions financially. These opportunities can help universities diversify their funding sources and achieve long-term financial sustainability.

Table 4: Benefits of Sustainable Financing

Benefit	Percentage
Improved Educational Quality	35%
Better Infrastructure	25%
Increased Research Opportunities	20%
Financial Stability	20%

This table shows the major benefits of sustainable financing in higher education. Improved educational quality is the most significant benefit, accounting for 35 percent.

Adequate financial resources enable institutions to hire qualified faculty, upgrade teaching methods, and provide better learning facilities. Better infrastructure represents 25 percent, including modern classrooms, laboratories, and digital learning resources. Increased research opportunities contribute 20 percent, supporting innovation and academic advancement. Financial stability also accounts for 20 percent, ensuring that institutions can manage their operations effectively without facing major financial crises. These benefits highlight the importance of adopting sustainable financial strategies in higher education.

Data Interpretation:

The statistical data presented in the tables provides a clear understanding of the financial structure, challenges, opportunities, and benefits associated with sustainable financing in higher education. Table 1 shows that government funding remains the primary source of financial support for higher education institutions, accounting for 45 percent of the total funding. This indicates that most universities and colleges still depend heavily on public investment. However, tuition fees also contribute significantly, representing 30 percent of the funding. This suggests that institutions are increasingly relying on student contributions to meet their financial needs. Private investment and donations contribute smaller percentages, highlighting the need for greater diversification of funding sources.

Table 2 focuses on the major financial challenges faced by higher education institutions. Insufficient government funding is identified as the most significant challenge, with 35 percent. Many governments are unable to provide adequate financial support due to budget constraints and competing priorities. Rising operational costs, including salaries, infrastructure maintenance, and technological upgrades, represent another major challenge. Increasing student enrollment also puts pressure on institutional resources, making it difficult for universities to maintain quality education. Limited private investment further complicates the financial situation.

Table 3 highlights various opportunities that can help institutions achieve sustainable financing. Public-private partnerships are identified as the most promising opportunity. These partnerships allow universities to collaborate with industries and private organizations for financial support, research funding, and technological development. Research funding and international collaboration also play important roles in improving financial sustainability. Alumni contributions provide an additional source of funding, particularly for scholarships, infrastructure development, and research activities. Table 4 illustrates the benefits of sustainable financing in higher education. The most significant benefit is improved educational quality. When institutions have stable financial resources, they can invest in qualified faculty, modern teaching methods, and advanced learning facilities. Sustainable financing also helps improve infrastructure and expand research opportunities. Furthermore, financial stability ensures that institutions can plan long-term development strategies without facing financial uncertainty.

Overall, the data indicates that sustainable financing is essential for the development and stability of higher education institutions. By addressing financial challenges and utilizing

available opportunities, universities can create a strong financial foundation that supports quality education, research, and institutional growth.

Findings:

The study reveals several important findings regarding sustainable financing in higher education. One of the key findings is that government funding remains the primary source of financial support for most higher education institutions. However, this funding is often insufficient to meet the increasing financial demands of universities and colleges. As student enrolment continues to grow and operational costs increase, institutions face significant financial challenges. Another important finding is the growing reliance on tuition fees as a source of funding. While tuition fees help institutions generate additional revenue, excessive dependence on student fees may create financial barriers for students from economically disadvantaged backgrounds. Therefore, institutions must balance financial sustainability with the goal of providing accessible education.

The study also highlights the importance of diversifying funding sources. Opportunities such as public-private partnerships, research funding, international collaborations, and alumni contributions can significantly improve the financial stability of higher education institutions. These alternative funding sources can reduce the dependence on government support and tuition fees. In addition, the findings suggest that sustainable financing can lead to several positive outcomes for higher education institutions. These include improved educational quality, better infrastructure, increased research opportunities, and greater financial stability. Institutions with strong financial resources are better equipped to invest in modern technology, hire qualified faculty, and support innovative research programs.

Overall, the study emphasizes that sustainable financing is essential for the long-term development of higher education systems. Effective financial management and diversified funding strategies are necessary to ensure that universities and colleges can continue to provide high-quality education while maintaining financial stability.

Conclusion:

Sustainable financing plays a vital role in ensuring the long-term development and stability of higher education institutions. The increasing demand for higher education, combined with rising operational costs and limited government funding, has created significant financial challenges for universities and colleges around the world. In this context, sustainable financing has emerged as an important approach for maintaining financial stability while supporting educational quality and institutional growth.The study highlights that traditional sources of funding, particularly government support, are no longer sufficient to meet the financial needs of higher education institutions. Therefore, it is essential for universities to adopt diversified funding strategies that include tuition fees, private investment, research funding, alumni contributions, and international collaborations. Such diversified financial models can help institutions reduce their dependence on a single source of funding and ensure long-term financial sustainability.

The research also emphasizes the importance of public-private partnerships and innovative financial mechanisms in strengthening the financial base of higher education institutions. These strategies can provide additional resources for infrastructure development, research activities, and technological advancement.In conclusion, sustainable financing is crucial for maintaining quality education, promoting research and innovation, and ensuring equal access to higher education. Policymakers, educational administrators, and stakeholders must work together to develop effective financial policies and strategies that support the long-term sustainability of higher education systems.

References

1. Altbach, P. G., & Salmi, J. (2011). *The road to academic excellence*. World Bank.
2. Barr, N. (2012). *Financing higher education*. Routledge.
3. Johnstone, D. B. (2010). *Higher education finance and cost sharing*. Boston College.
4. Jongbloed, B. (2004). Funding higher education. *Higher Education Policy*, 17(1).
5. Salmi, J. (2017). *The tertiary education imperative*. Sense Publishers.
6. Tilak, J. B. G. (2015). Higher education in India. *Economic and Political Weekly*.
7. UNESCO. (2015). *Rethinking education*. UNESCO Publishing.
8. Varghese, N. V. (2013). *Governance reforms in higher education*. UNESCO.
9. World Bank. (2018). *Higher education finance report*.
10. OECD. (2019). *Education at a glance*. OECD Publishing.
11. Agarwal, P. (2012). *Higher education in India*. Sage Publications.
12. Altbach, P. G. (2016). *Global perspectives on higher education*.
13. Marginson, S. (2011). Higher education and public funding.
14. Shattock, M. (2013). *Managing successful universities*.
15. Teixeira, P. (2014). *Funding challenges in higher education*.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

SUSTAINABLE DEVELOPMENT GOAL 4 (SDG-4) AND THE TRANSFORMATION OF HIGHER EDUCATION IN INDIA: POLICY REFORMS AND BUDGET 2026 INITIATIVES

Dr. Vidya M. Jirage
Associate Professor of Commerce,
Government First Grade College, Khanapur
Dist- Belagavi 591302 State- Karnataka, India
Contact No.- 9731576457
E-mail: vidyajirage@gmail.com

Abstract:

Education is widely recognized as a powerful instrument for social transformation, economic growth, and sustainable development. The **United Nations Sustainable Development Goal 4 (SDG-4)** aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all by 2030. As one of the world's largest education systems, India plays a critical role in achieving this global goal. In recent years, the Indian government has introduced significant reforms to strengthen higher education through policies such as the **National Education Policy (NEP) 2020**, digital learning initiatives, and institutional restructuring.

This paper examines the impact of SDG-4 on higher education in India and analyzes recent policy developments, including the **Union Budget 2026 announcements** and higher education reforms implemented up to 2026. Key initiatives such as the **Academic Bank of Credits, Digital University initiative, SWAYAM online learning platform, National Institutional Ranking Framework (NIRF), university townships, and research funding programs** are discussed.

The study highlights how these reforms aim to expand access to education, improve quality, strengthen research, and align education with emerging economic sectors. Despite progress in enrollment growth, digital learning, and institutional expansion, challenges such as the digital divide, quality disparities, and employability gaps remain. The paper concludes that sustained policy implementation, technological integration, and inclusive governance are essential for achieving SDG-4 and transforming India into a global knowledge economy.

Keywords

Sustainable Development Goals, SDG-4, Higher Education, NEP-2020, Digital Learning, Budget 2026, Inclusive Education, Academic Bank of Credits

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Introduction:

Education is a fundamental driver of sustainable development and human progress. Recognizing its significance, the **United Nations adopted the 2030 Agenda for Sustainable Development in 2015**, consisting of **17 Sustainable Development Goals (SDGs)** aimed at addressing global challenges such as poverty, inequality, climate change, and education.

Among these goals, **SDG-4 focuses on ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all**. Education not only empowers individuals but also strengthens societies by promoting economic development, social inclusion, and technological advancement.

Higher education institutions play a crucial role in achieving SDG-4 because they serve as centers for knowledge creation, research, innovation, and skill development. Universities and colleges prepare students for professional careers while contributing to national development through research and technological innovation.

India has one of the largest higher education systems in the world, with thousands of universities and colleges serving millions of students. In recent years, the government has undertaken significant reforms to align higher education with the objectives of SDG-4. Policies such as the **National Education Policy (NEP) 2020**, digital learning platforms, and institutional reforms have been introduced to improve accessibility, quality, and employability.

Furthermore, the **Union Budget 2026** introduced several new initiatives to strengthen higher education infrastructure, promote research and innovation, and expand opportunities for students across the country. These developments demonstrate India's commitment to transforming its education system and achieving the global education targets set by the United Nations.

Understanding Sustainable Development Goal 4

SDG-4 aims to ensure inclusive, equitable, and quality education while promoting lifelong learning opportunities for all. The goal emphasizes not only access to education but also the quality and relevance of learning outcomes.

Key targets of SDG-4 include:

- Universal access to quality primary and secondary education
- Equal access to affordable technical and higher education
- Elimination of gender disparities in education
- Promotion of vocational and technical skills
- Expansion of lifelong learning opportunities

- Improvement in literacy and digital skills

Higher education institutions play a critical role in achieving these targets by providing advanced knowledge, promoting innovation, and preparing skilled professionals who contribute to national and global development.

Status of Higher Education in India

India's higher education sector has expanded significantly over the last two decades. According to the **All India Survey on Higher Education (AISHE)**, the country now has:

- Over **1,100 universities**
- More than **43,000 colleges**
- Student enrollment exceeding **4.3 crore students**
- A **Gross Enrollment Ratio (GER)** of around **28 percent**
- Female enrollment has grown significantly, with women accounting for nearly **49% of total students**.

The participation of women in higher education has increased considerably, with female students representing nearly half of the total enrollment. Government policies such as scholarships, reservation systems, and financial assistance programs have played an important role in expanding educational opportunities for marginalized communities.

Despite this growth, challenges remain in terms of quality improvement, equitable access, and employability of graduates.

Major Government Initiatives Supporting SDG-4

1. National Education Policy (NEP) 2020 : The **National Education Policy 2020** represents a comprehensive reform aimed at transforming India's education system. The policy focuses on flexibility, multidisciplinary education, and improved research infrastructure.

Key features include:

- Multidisciplinary universities and holistic education
- Flexible degree structures with multiple entry and exit options
- Promotion of vocational education and skill development
- Establishment of the **National Research Foundation**
- Internationalization of Indian universities

NEP-2020 strongly aligns with SDG-4 by emphasizing accessibility, inclusiveness, quality, affordability, and accountability and innovation.

2. Digital Learning Platforms : Digital technology has significantly expanded access to education in India. Several government initiatives support online learning and digital education. Major digital initiatives include:

- **SWAYAM:** An online learning platform providing free courses from leading institutions such as IITs and IIMs.
- **SWAYAM PRABHA :** Satellite channels broadcasting educational content across India.
- **National Digital Library of India (NDLI) :** A digital repository providing access to millions of academic resources.

These platforms enable students from remote areas to access quality education, thereby supporting the goals of lifelong learning.

3. Academic Bank of Credits : The **Academic Bank of Credits (ABC)** allows students to store academic credits earned from different institutions and transfer them when required.

Benefits include:

- Flexibility in learning pathways
- Mobility between institutions
- Recognition of online and offline learning credits

This system promotes a student-centric education model.

4. National Institutional Ranking Framework (NIRF) : The **National Institutional Ranking Framework** evaluates higher education institutions based on several parameters including teaching quality, research output, and inclusiveness.

NIRF encourages institutions to maintain high standards of academic performance and transparency.

5. Digital University Initiative : The **Digital University of India**, announced in recent budgets, aims to provide high-quality online degree programs and expand access to higher education for students across the country.

This initiative reduces geographical barriers and enhances educational accessibility.

Impact of SDG-4 on Higher Education

- **Improved Access to Education:** Government initiatives have increased enrollment and expanded opportunities for students from rural and economically weaker backgrounds. Government initiatives such as **scholarships, reservation policies, and**

digital learning platforms have expanded access to higher education, especially for marginalized communities. Programs like **PM-Vidya, e-Vidya, and online courses** have enabled students in remote areas to continue their education.

- **Inclusive Education :** Policies supporting gender equality and social inclusion have significantly increased participation of women and marginalized communities.
- **Research and Innovation :** Programs such as the National Research Foundation and Startup India encourage universities to engage in research and technological development.
- **Skill Development :** Skill-based programs help students acquire practical competencies required in modern industries.

Promotion of Inclusive Education :

SDG-4 emphasizes equality in education. India has implemented several initiatives to promote inclusiveness:

- Scholarships for economically weaker sections
- Gender-inclusive policies
- Special programs for tribal and rural students

As a result, the participation of women and underrepresented groups in higher education has increased significantly.

Strengthening Research and Innovation : Research is essential for sustainable development. India has introduced initiatives such as:

- **National Research Foundation**
- **Atal Innovation Mission**
- **Startup India programs**

Universities are increasingly becoming hubs for innovation and entrepreneurship.

Skill Development and Employability : One major objective of SDG-4 is to equip learners with skills relevant to employment. Programs supporting skill development include:

- **Skill India Mission**
- **Pradhan Mantri Kaushal Vikas Yojana**
- **Industry-academia collaborations**

These initiatives aim to bridge the gap between education and employment.

Recent Higher Education Reforms and Union Budget 2026 Announcements

- **Increased Education Budget :** The **Union Budget 2026–27** increased funding for the education sector to approximately **₹1.39 lakh crore**, with more than **₹41,000 crore allocated for higher education**. Increased financial support aims to strengthen research infrastructure, improve teaching quality, and modernize universities.
- **Establishment of University Townships :** The government announced the creation of **five university townships near major industrial hubs**. These townships will include universities, research centers, industry collaboration spaces, and residential facilities.

This initiative is designed to promote **industry-academia collaboration** and strengthen innovation ecosystems.

- **Content Creation and Digital Skill Labs :**To support emerging creative industries, the government plans to establish **Content Creation Labs** focusing on animation, gaming, visual effects, and digital media. These labs aim to equip students with skills required in modern digital industries.
- **Women's Education Infrastructure :** To improve access to higher education for female students, the government announced the establishment of **girls' hostels in every district**. This initiative addresses safety and accommodation challenges faced by students from rural areas.
- **Expansion of Specialized Institutions:** The government plans to establish new institutions such as:
    - National Institute of Design in eastern India
    - National Institute of Hospitality
    - New institutes for Ayurveda and allied health sciences

These institutions will diversify educational opportunities and support emerging sectors.

- **Research and Innovation Programs :** The government has launched research initiatives such as **Biopharma SHAKTI**, with an allocation of around **₹10,000 crore**, to promote advanced research and innovation in biotechnology and pharmaceutical sectors.

RECENT EXAMPLES OF PROGRESS IN HIGHER EDUCATION

Example 1: Expansion of Premier Institutions

India has significantly expanded its network of premier institutions. The country now has **23 IITs, 21 IIMs, and 20 AIIMS**, strengthening research and professional education capacity.

Example 2: Tamil Nadu's Higher Education Enrolment

Tamil Nadu has one of the highest higher-education participation rates in India. Many districts have implemented counselling and financial assistance programs to encourage students to pursue higher education.

For example, in **Tiruchirappalli district**, nearly **98% of government school students enrolled in colleges** after completing Class XII due to career guidance and financial support programs.

Example 3: Rise of Skill-Based Education

Students are increasingly shifting from traditional courses to **professional and skill-oriented programs**, reflecting changing employment trends and industry requirements.

Example 4: Growth of Digital Universities

Digital universities and online learning platforms are expanding access to higher education, especially for working professionals and rural students.

Challenges in Achieving SDG-4 : Despite progress, several challenges remain:

- **Digital Divide :** Limited internet access in rural areas restricts participation in digital education.
- **Quality Disparities :**There are significant differences in academic quality among institutions.
- **Funding Constraints :**Many institutions require greater financial support for research and infrastructure.
- **Employability Gap :**There remains a gap between academic learning and industry requirements.
- **Regional Disparities :** Educational infrastructure varies widely across states and districts. Many rural areas still lack adequate colleges and universities.
- **Quality of Education :**Some institutions suffer from outdated curricula, limited research facilities, and insufficient faculty.

Future Prospects: India has strong potential to emerge as a global education hub. Key strategies for the future include:

- Expanding digital infrastructure
- Increasing research funding
- Encouraging global collaboration between universities
- Promoting interdisciplinary learning
- Strengthening industry partnerships

These measures will help India achieve SDG-4 while supporting sustainable economic growth.

Conclusion

Sustainable Development Goal 4 highlights the importance of inclusive, equitable, and quality education as a foundation for sustainable development. India has made considerable progress in aligning its higher education system with the objectives of SDG-4 through policy reforms, digital learning initiatives, and institutional expansion.

Policies such as **NEP-2020**, digital learning platforms, and initiatives like the **Academic Bank of Credits and Digital University** have significantly improved accessibility and flexibility in education. Furthermore, the **Union Budget 2026 announcements**, including increased funding, university townships, research programs, and infrastructure for women's education, demonstrate the government's strong commitment to strengthening higher education.

However, achieving the full vision of SDG-4 requires addressing challenges such as the digital divide, quality disparities, and skill gaps. Continuous policy innovation, investment in research and technology, and collaboration between government, academia, and industry will be essential.

By strengthening its higher education ecosystem, India can not only achieve SDG-4 but also empower millions of learners to contribute to national development and global sustainability.

References

1. Tilak, J.B.G. (2018). Education and Development in India. Palgrave Macmillan.
2. Agarwal, P. (2012). Indian Higher Education: Envisioning the Future. Sage Publications.
3. Altbach, Philip G., & Salmi, Jamil (2011). The Road to Academic Excellence. World Bank Publications.
4. Gupta, Asha (2019). Higher Education in India: Growth and Challenges. Routledge.
5. Tilak, J.B.G. (2013). Higher Education in India: In Search of Equality, Quality and Quantity.
6. United Nations (2015). Transforming Our World: The 2030 Agenda for Sustainable Development.
7. Government of India (2020). National Education Policy 2020. Ministry of Education.
8. Ministry of Education (2024). All India Survey on Higher Education (AISHE) Report.
9. NITI Aayog (2024). SDG India Index Report.
10. UNESCO (2023). Global Education Monitoring Report.
11. Ministry of Finance (2026). Union Budget 2026–27 Highlights. Government of India.
12. University Grants Commission (UGC). Academic Bank of Credits Guidelines.

13. Ministry of Education. SWAYAM and Digital Learning Initiatives.
14. PRS Legislative Research. Budget Analysis of Education Sector 2026–27.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

SUSTAINABLE FINANCING AND HIGHER EDUCATION

Pratiksha Ansurkar
Research Scholar, Department of Commerce,
Rani Channamma University, Belagavi.
Phone: 9448038216
Email: pratikshaa938@gmail.com

Abstract:

Higher education plays a vital role in the social, economic, and technological development of a nation. However, the increasing cost of education, limited government funding, and growing demand for quality education have created significant financial challenges for higher education institutions. Sustainable financing has therefore emerged as an important approach to ensure the long-term stability and growth of universities and colleges. Sustainable financing in higher education refers to the adoption of financial strategies that ensure adequate funding while maintaining efficiency, accountability, and accessibility for students. It includes diversified funding sources such as government grants, private investment, research funding, endowments, public–private partnerships, and innovative financial mechanisms.

In recent years, many countries have attempted to strengthen higher education financing by introducing reforms that encourage institutional autonomy, resource mobilization, and financial transparency. At the same time, sustainable financing aims to balance financial sustainability with social responsibility so that education remains accessible and affordable to all sections of society.

This paper examines the concept of sustainable financing in higher education, reviews existing literature on the subject, and discusses the key challenges and opportunities associated with implementing sustainable financial strategies. The study highlights the importance of diversified funding models, efficient financial management, and supportive policy frameworks to ensure the long-term sustainability of higher education institutions.

Keywords: Sustainable Financing, Higher Education, Financial Sustainability, Education Funding, Public–Private Partnership, Institutional Development

1. Introduction

Higher education is considered one of the most important pillars for national development and human capital formation. Universities and higher education institutions play a crucial role in generating knowledge, promoting innovation, and developing skilled human resources required for economic progress. Over the years, the demand for higher education has increased significantly due to population growth, globalization, and the expansion of knowledge-based

industries. However, the rapid expansion of the higher education sector has also created financial pressures on governments and educational institutions.

Traditionally, higher education in many countries has been largely funded by governments through public expenditure. Global education spending averages about **4.2–4.9% of GDP across many countries**, showing that education remains a major component of national budgets. However, investment specifically in tertiary education varies significantly across countries. For example, in some nations spending on higher education reaches around **2.4% of GDP**, while in others it is less than **0.5% of GDP**

Globally, the demand for higher education has increased significantly during the last two decades. The global gross enrollment ratio in higher education increased from 27% in 2010 to about 40% in 2021, indicating rapid expansion of the sector. At the same time, global spending on higher education is estimated to exceed $1.8 trillion annually, reflecting the growing economic importance of universities and research institutions. However, many countries still struggle to finance their higher education systems adequately due to limited public resources, rising operational costs, and increasing student enrollment.

In recent years, governments, policymakers, and educational institutions have recognized the need for innovative financing strategies to strengthen the higher education system. Approaches such as public–private partnerships, research grants, philanthropic contributions, and international collaborations have gained importance. These mechanisms not only provide additional financial resources but also promote institutional development and global competitiveness.

The concept of sustainable financing is particularly important in developing countries where higher education institutions often face limited financial resources and increasing student enrolment. Without proper financial planning and resource management, institutions may struggle to maintain academic quality and infrastructure development. Therefore, adopting sustainable financing strategies is essential for ensuring the long-term growth and stability of the higher education sector.

2. Review of Literature

1. **Johnstone (2004)** "The Economics and Politics of Cost Sharing in Higher Education" Johnstone examined the growing financial pressures faced by higher education institutions worldwide and discussed the concept of cost sharing between governments, institutions, and students. The study highlighted that sustainable financing requires diversified funding sources rather than complete dependence on public funding. The author emphasized the role of tuition fees, private investment, and institutional autonomy in ensuring financial stability. The research concluded that cost-sharing mechanisms can support the expansion of higher education while maintaining financial sustainability.
2. **Altbach, Reisberg and Rumbley (2009)** "Trends in Global Higher Education: Tracking an Academic Revolution" This study analyzed global developments in higher education

systems and highlighted the financial challenges faced by universities in both developed and developing countries. The authors noted that the expansion of higher education requires significant financial resources and innovative funding strategies. The research emphasized the importance of government support combined with private funding and international partnerships to ensure sustainable financing. The study also pointed out that financial sustainability is closely linked to institutional governance and management practices.

3. **Salmi (2011)** "The Challenge of Establishing World-Class Universities" Salmi explored the financial requirements for developing high-quality universities and emphasized the need for sustainable financial models. According to the study, world-class universities require strong financial resources, research funding, and effective governance structures. The author highlighted the role of diversified funding sources such as endowments, research grants, and private sector collaboration. The study concluded that sustainable financing is essential for maintaining academic excellence and global competitiveness.
4. **Barr (2012)** "Financing Higher Education: Lessons from Economic Theory and Reform in England" Barr examined the reforms in higher education financing in England and discussed the economic principles behind sustainable funding models. The study focused on the balance between public funding and student contributions. The author argued that well-designed financing systems can promote efficiency, equity, and sustainability in higher education. The research also highlighted the importance of policy frameworks in supporting long-term financial stability.
5. **Tilak (2015)** "Higher Education in India: In Search of Equality, Quality and Quantity" Tilak analyzed the challenges faced by the higher education system in India, particularly in terms of financial resources and quality improvement. The study highlighted that insufficient public funding and uneven distribution of resources have affected institutional development. The author suggested that sustainable financing strategies should include increased government investment, institutional revenue generation, and improved financial management.
6. **World Bank (2017)** "Higher Education Financing for Sustainability" The World Bank report examined different models of financing higher education across countries. The report emphasized that sustainable financing requires a balanced combination of public funding, private investment, and institutional resource mobilization. It also highlighted the importance of accountability, transparency, and efficient financial planning in higher education institutions**.**
7. **Chapman (2006)** "Income Contingent Loans for Higher Education: International Reforms*"* examined the role of income-contingent loan systems in financing higher education across different countries. The study focused on how student loan programs can support sustainable financing while ensuring equitable access to education. According to the author, traditional funding models based solely on government support are often insufficient to meet the increasing demand for higher education. Income-contingent loan schemes allow students to

repay their education loans after securing employment and earning a stable income, thereby reducing the financial burden during their study period.

The research highlighted that countries such as Australia and the United Kingdom have successfully implemented income-contingent loan systems to balance financial sustainability and social equity in higher education. The study concluded that such financing mechanisms can reduce pressure on government budgets while expanding access to higher education. However, it also emphasized the need for effective policy design and administrative efficiency to ensure the long-term sustainability of student loan programs.

8. **Johnstone and Marcucci (2010)** "Financing Higher Education Worldwide: Who Pays and Who Should Pay**?** analyzed different financing models used by higher education systems across the world. The study explored the concept of cost sharing among governments, students, families, and private institutions. According to the authors, the increasing cost of higher education has forced many countries to reconsider traditional financing structures and adopt diversified funding approaches.

   The study emphasized that sustainable financing requires a balanced combination of public funding, tuition fees, private sector investment, and institutional revenue generation. The authors also highlighted that financial reforms should focus on maintaining both efficiency and equity in higher education systems. They concluded that effective financing strategies must ensure that universities remain financially stable while also providing equal opportunities for students from different socio-economic backgrounds.

9. **Marginson (2016)** "The Worldwide Trend to High Participation Higher Education*"* examined the rapid global expansion of higher education and its implications for financing and policy development. The study observed that many countries have experienced a significant increase in student enrollment as higher education becomes more accessible and essential for economic growth. This expansion has created substantial financial challenges for governments and institutions, as additional resources are required to maintain quality education and research activities.

   The research highlighted that sustainable financing models are essential for supporting the growing demand for higher education. The author suggested that governments should adopt diversified funding mechanisms that include public investment, private partnerships, and institutional revenue generation. The study concluded that effective financial planning and policy reforms are necessary to ensure that higher education systems remain inclusive, high-quality, and financially sustainable in the long term.

3. Objectives of the Study

1. To understand the concept of sustainable financing in higher education.
2. To examine the importance of sustainable financial strategies for universities.
3. To identify the challenges faced in financing higher education.
4. To analyse opportunities and alternative funding sources for sustainable development of higher education institutions.

4. Hypothesis of the study

H01: Sustainable financing has no significant role in the development of higher education institutions.
H11: Sustainable financing plays a significant role in the development of higher education institutions.
H02: Sustainable financial strategies do not significantly influence the efficiency and quality of universities
H12: Sustainable financial strategies significantly influence the efficiency and quality of universities.
H03: Higher education institutions do not face significant challenges in financing their activities.
H13: Higher education institutions face significant challenges in financing their activities.
H04: Alternative funding sources do not significantly contribute to the sustainable development of higher education institutions.
H14: Alternative funding sources significantly contribute to the sustainable development of higher education institutions.

5. Research Methodology

The present study is primarily based on secondary data. Information has been collected from research journals, books, government reports, policy documents, and reports published by international organizations such as UNESCO and the World Bank. The collected data has been analyzed using descriptive and analytical methods to examine the concept, challenges, and opportunities related to sustainable financing in higher education.

6. Current Trends in Higher Education Financing

The financing structure of higher education has undergone significant transformation over the last few decades. Traditionally, universities and colleges were largely dependent on government funding to support teaching, research, and infrastructure development. However, increasing enrollment, technological advancements, and rising operational costs have forced higher education institutions to explore diversified and sustainable financing models.

In many developed economies, public funding continues to play an important role in financing higher education. In countries belonging to the Organisation for Economic Co-operation and Development (OECD), public funding accounts for nearly 68 percent of the total expenditure on higher education, while the remaining share is generated through tuition fees, private investment, research grants, and philanthropic contributions. This mixed financing model helps universities maintain financial stability while expanding their academic and research activities.

Another major trend in higher education financing is the increasing investment in research and innovation. Universities are now recognized as important centers for scientific research and

technological development. Global expenditure on research and development within universities is estimated to reach nearly $450 billion annually, with a large share of investment coming from G20 countries. Research funding from governments, industries, and international organizations plays a significant role in strengthening university finances and promoting knowledge creation.

In developing countries, the expansion of higher education systems has also increased the demand for financial resources. According to reports from UNESCO, global enrollment in tertiary education has increased from around 100 million students in 2000 to more than 235 million students in recent years. This rapid growth has created significant pressure on governments to provide adequate funding for universities and colleges.

In India, the higher education system is one of the largest in the world. According to the All-India Survey on Higher Education (AISHE), India currently has more than 1,100 universities and over 43,000 colleges, with a Gross Enrollment Ratio of around 28–29 percent. The expansion of institutions and student enrollment has significantly increased the financial requirements of the higher education sector.

Despite these developments, many countries continue to face a serious financing gap. Global education reports estimate that there is nearly a $97 billion annual funding gap in achieving international education goals, particularly in developing nations. This gap highlights the importance of adopting sustainable and diversified financing strategies in higher education systems.

7. Challenges in Sustainable Financing of Higher Education

Although sustainable financing has become a major priority for policymakers and universities, several challenges continue to hinder its effective implementation.

1. Limited Public Funding

Government funding remains the primary source of finance for many higher education institutions. However, many governments face fiscal constraints and competing priorities such as healthcare, infrastructure development, and social welfare programs. As a result, public expenditure on higher education often remains insufficient to meet the growing needs of universities.

2. Increasing Operational Costs

The cost of running universities has increased significantly in recent years. Institutions must invest in modern infrastructure, digital learning platforms, advanced laboratories, libraries, and research facilities. Additionally, faculty salaries, administrative expenses, and maintenance costs have also increased, placing additional financial pressure on institutions.

3. Rapid Expansion of Higher Education

The growing demand for higher education has led to a rapid expansion of universities and colleges. While this expansion improves access to education, it also requires substantial financial resources for infrastructure development, faculty recruitment, and academic programs.

4. Inequality in Access to Resources

There is a significant disparity in financial resources among higher education institutions. Elite universities often receive more funding and research grants, while smaller or rural institutions struggle with limited financial resources. This inequality can affect the quality of education and research opportunities available to students.

5. Dependence on Tuition Fees

Many universities increasingly depend on tuition fees to generate revenue. While tuition fees help institutions cover operational costs, excessive reliance on student fees may limit access to higher education for students from economically weaker sections of society.

6. Weak Financial Management

In some institutions, lack of proper financial planning and management can lead to inefficient use of resources. Poor budgeting, lack of transparency, and weak governance structures can negatively affect financial sustainability.

7. Limited Industry Collaboration

Another challenge is the limited collaboration between universities and industries in some countries. Strong partnerships between academia and industry can generate research funding and innovation opportunities, but such collaborations are still underdeveloped in many higher education systems.

8. Opportunities for Sustainable Financing

Despite these challenges, several opportunities exist for improving the financial sustainability of higher education institutions.

1. Public–Private Partnerships

Public–private partnerships (PPP) can play an important role in financing higher education infrastructure and research projects. Through PPP models, governments and private organizations collaborate to build universities, research centers, and innovation hubs.

2. Research Grants and Innovation Funding

Universities can generate significant revenue through research grants from government agencies, private industries, and international organizations. Research collaboration with industries can also help universities commercialize innovations and generate additional income.

3. Alumni Contributions and Endowment Funds

Alumni networks are an important source of financial support for many universities. Successful alumni often contribute through donations, scholarships, and endowment funds. Endowments provide long-term financial stability by generating investment income for universities.

4. International Collaboration

Global partnerships with foreign universities and international institutions can provide access to funding opportunities, research grants, and academic exchange programs. Such collaborations also improve institutional reputation and global competitiveness.

5. Digital Education and Online Programs

The rapid growth of digital technology has created new opportunities for universities to offer online courses and distance education programs. These programs can reach a larger number of students and generate additional revenue while reducing infrastructure costs.

6. Skill Development and Industry-Oriented Courses

Universities can introduce skill-based and professional courses that meet industry requirements. Such programs attract more students and increase employability, while also generating additional income for institutions.

7. Government Policy Reforms

Supportive government policies that encourage institutional autonomy, financial accountability, and research funding can strengthen the financial sustainability of higher education institutions.

9. Data Analysis and Interpretation

Table 1: Growth of Higher Education in India

Particulars	2010	2015	2022
Number of Universities	523	760	1,100+
Number of Colleges	33,000	39,000	43,000+
Student Enrollment	27 million	34 million	41 million

Interpretation:
The table shows that the number of universities, colleges, and student enrollment has increased significantly in India. This rapid growth has increased the demand for financial resources in higher education institutions. Therefore, sustainable financing is essential for maintaining infrastructure, faculty development, and research activities.

Table 2: Sources of Funding for Higher Education Institutions

Source of Funding	Percentage
Government Grants	55–60%
Student Fees	25–30%
Research Grants	5–10%
Donations / Industry Collaboration	5–8%

Interpretation:
The table indicates that higher education institutions depend on multiple funding sources. While government funding remains the major source, universities are increasingly relying on tuition fees, research funding, and industry collaborations. This highlights the importance of diversified and sustainable financial strategies.

Verification of Hypotheses

The analysis of secondary data from reports of the All-India Survey on Higher Education and University Grants Commission shows that higher education institutions require stable financial resources for their development. The growth of institutions and student enrollment has increased financial requirements. At the same time, universities face financial challenges due to limited government funding and rising operational costs. Therefore, institutions are exploring alternative funding sources such as research grants, industry partnerships, and alumni contributions to achieve sustainable development. Based on this analysis, the formulated hypotheses are supported.

10. Findings of the Study

1. Sustainable financing plays a crucial role in the development and functioning of higher education institutions.
2. Financial sustainability helps universities maintain infrastructure, research activities, and academic quality.

3. Higher education institutions face several financial challenges such as limited public funding and increasing operational costs.
4. The growth of higher education institutions has increased the need for diversified funding sources.
5. Alternative funding sources such as research grants, industry collaborations, and alumni donations support the sustainable development of universities.

11. Suggestions / Policy Recommendations

1. Increase Government Funding:

   The government should increase financial support to higher education institutions to ensure quality education, research development, and infrastructure improvement.

2. Encourage Public–Private Partnerships:

   Universities should collaborate with industries and private organizations to generate additional financial resources and promote innovation and research.

3. Promote Research Grants and Projects:

   Higher education institutions should actively participate in national and international research projects to obtain research funding and improve academic standards.

4. Develop Alumni Funding Systems:

   Universities should strengthen alumni networks and encourage alumni donations to support institutional development.

5. Adopt Efficient Financial Management:

   Institutions should implement effective financial planning and resource management strategies to ensure long-term sustainability.

12. Conclusion

Sustainable financing plays a crucial role in the development and growth of higher education institutions. The increasing number of universities, colleges, and student enrollment has significantly increased the demand for financial resources in the education sector. Higher education institutions require adequate funding to maintain infrastructure, promote research activities, and ensure quality education. However, many institutions face financial challenges due to limited government support and rising operational costs. Therefore, it is essential for universities to adopt sustainable financial strategies and explore alternative funding sources such as research grants, public–private partnerships, industry collaboration, and alumni contributions. These strategies will help institutions achieve financial stability and support long-

term development. Thus, sustainable financing is essential for strengthening higher education systems and promoting inclusive and quality education.

13. References

Articles

1. Johnstone (2004) – *The Economics and Politics of Cost Sharing in Higher Education*
2. Altbach, Reisberg & Rumbley (2009) – *Trends in Global Higher Education: Tracking an Academic Revolution*
3. Salmi (2011) – *The Challenge of Establishing World-Class Universities*
4. Barr (2012) – *Financing Higher Education: Lessons from Economic Theory and Reform in England*
5. Tilak (2015) – *Higher Education in India: In Search of Equality, Quality and Quantity*
6. World Bank (2017) – *Higher Education Financing for Sustainability*
7. Chapman (2006) – *Income Contingent Loans for Higher Education: International Reforms*
8. Johnstone & Marcucci (2010) – *Financing Higher Education Worldwide: Who Pays and Who Should Pay?*
9. Marginson (2016) – *The Worldwide Trend to High Participation Higher Education*

Books

1. **Higher Education Financing in India: Student Loans and Equity in Access**
2. **Financing of Higher Education: Traditional Approaches and Innovative Strategies**

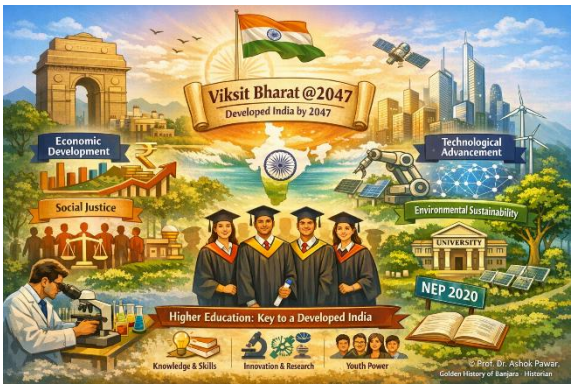
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

THE ROLE OF HIGHER EDUCATION IN VIKASHIT BHARAT@2047: INCLUSIVE SUSTAINABLE DEVELOPMENT

Dr. Ashok Shankarrao Pawar[1] and Prof. (Dr.) Bhausaheb Y. Deshmukh[2]
[1]Professor and Head of the Department of Economics
Dr. Babasaheb Ambedkar Marathwada University,
Chhatrapati Sambhajinagar
Phone: 8080891092
[2]Principal, Adv. M.N.Deshmukh
Arts, Commerce College,Rajur TalAkole
Dist-Ahilyanagar
Phone: 8766573007

Introduction

As India moves towards completing 100 years of independence, it has set the vision of "Viksit Bharat @2047" (Developed India by 2047). The core pillars of this vision include economic development, social justice, environmental sustainability, and technological advancement. The higher education system plays a crucial role in achieving these objectives.



Higher education promotes the growth of knowledge, skills, innovation, and research within society. In a country like India with a large population, especially a significant youth population, improving the quality of higher education is essential to harness this demographic advantage.

Today, through the National Education Policy 2020 (NEP 2020), significant reforms are being introduced in the education sector. To transform India into a developed nation by 2047, the role of higher education institutions, research centers, and universities will be decisive.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Keywords:
Sustainable Development, Higher Education in India, Developed India @2047, National Education Policy 2020 (NEP 2020), Human Resource Development.

Objectives of the Study

The main objectives of this research are as follows:

1. To analyze the concept of **Sustainable Development** in India.
2. To explain the role of **higher education** in India's development.
3. To study the current challenges in the **higher education sector**.
4. To suggest reforms in **higher education** for achieving development by **2047**.

Research Methodology

Secondary data has been used for this research.
The sources of information are as follows:

- Research books
- Government reports
- Academic journals
- UGC and AICTE reports
- National Education Policy 2020 (NEP 2020)

The information has been analyzed using the descriptive method**.**

Concept of Sustainable Development

Sustainable development refers to a form of development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. This concept was introduced in 1987 by the Brundtland Commission**.**

Sustainable development is based on three major pillars:

1. Economic Development

Economic development is considered one of the most important components of a nation's progress. Economic development does not merely refer to an increase in a country's income or production, but it broadly includes improvement in the standard of living of people, expansion of employment opportunities, growth of industries and businesses, and achieving economic stability through the proper utilization of resources.

In modern times, the concept of economic development has expanded and has become closely associated with the principles of sustainable development. Therefore, while achieving economic growth, equal importance is given to environmental protection, social equity, and balanced utilization of resources.

Traditionally, economic development was mainly associated with industrialization, increase in production, and expansion of trade. However, after the industrial revolution, large-scale industrial growth took place worldwide. Along with this growth came serious problems such as excessive exploitation of natural resources, pollution, climate change, and environmental imbalance. As a result, a new concept emerged that economic development should not harm the environment but should instead be environmentally friendly. This is known as sustainable or environmentally responsible economic development.

Industries and technology play a crucial role in economic development. Modern technology increases efficiency in production processes, reduces wastage of resources, and improves product quality. Digital technologies, artificial intelligence, information technology, and automated systems have brought major transformations in the industrial sector. These advancements not only increase economic output but also create new employment opportunities.

Employment generation is a very important aspect of economic development because employment increases people's income, improves their standard of living, and helps in reducing poverty in society.

Poverty eradication is one of the main objectives of economic development. The development of a country is considered meaningful only when its benefits reach all sections of society and when the basic needs of people such as food, clothing, shelter, education, and healthcare are fulfilled. Economic development increases investment in sectors like education and health, which in turn leads to the development of human resources and strengthens society.

Efficient and balanced utilization of resources is another important component of economic development. Natural resources on Earth are limited, and therefore they must be used with a long-term perspective. Proper planning and utilization of energy, water, minerals, and forest resources can ensure sustainable economic development. Excessive exploitation of resources may deprive future generations of these resources, which is why resource management is given special importance in the concept of sustainable development.

In the present era, green technology has become an important tool for directing economic development in an environmentally friendly manner. The main objective of green technology is to reduce the negative impact of industrial and production activities on the environment. For

example, energy-efficient machines, pollution-reducing technologies, and recycling practices are making industries more sustainable.

The use of renewable energy sources is also an important part of sustainable economic development. Energy sources such as solar energy, wind energy, hydro energy, and bioenergy reduce dependence on fossil fuels and help in reducing environmental pollution. Since these sources are renewable and long-lasting, they can help meet future energy demands.

In the agricultural sector as well, sustainable farming practices contribute to economic development. Organic farming, water conservation, soil conservation, and the use of modern agricultural technologies increase productivity while also protecting the environment. Sustainable agriculture increases farmers' income and strengthens the rural economy.

In India, several policies and programs are being implemented to promote sustainable economic development. Solar energy projects, expansion of the digital economy, promotion of green industries, and adoption of sustainable agricultural practices are providing a new direction to the country's economic growth. India has achieved a significant position in global solar energy production, and many cities are developing green energy projects. Digital technology has also transformed trade, services, and industrial sectors.

Thus, it is clear that economic development is not limited to the growth of production or income alone but is related to the overall progress of society. Economic development that balances environmental protection, social justice, and proper utilization of resources can truly be called sustainable development.



2. Social Equity

Social equity is an extremely important component of the concept of sustainable development. Social equity refers to providing equal opportunities, equal rights, and fair access to resources for every individual in society.

In society, significant inequalities exist in economic, social, educational, and cultural aspects. Some groups remain in the mainstream of development, while others remain marginalized or deprived. Therefore, the main objective of social equity is to provide equal opportunities to all sections of society and ensure that the benefits of development reach everyone.

Social equity is not limited to equality alone but is also related to justice and inclusiveness. It includes providing opportunities for advancement to weaker and marginalized sections of society such as women, Scheduled Castes, Scheduled Tribes, nomadic and denotified tribes, persons with disabilities, and economically weaker sections.

If certain sections of society remain excluded from the development process, comprehensive social progress becomes impossible.

Education is one of the most powerful tools for achieving social equity. Education enhances knowledge, develops skills, and creates employment opportunities. Therefore, every individual in society must have equal access to quality education. Education helps reduce social discrimination and increases awareness among people. For this reason, many countries implement inclusive educational policies to bring marginalized groups into the mainstream of education.

Healthcare services are also an important part of social equity. All individuals in society must have access to basic healthcare services. When people living in poor or remote areas do not have access to healthcare, their standard of living is negatively affected. Therefore, governments implement various healthcare programs and policies to ensure that healthcare services are available to all citizens.

Gender equality is another important dimension of social equity. In many societies, women face restrictions in education, employment, property rights, and participation in decision-making processes. Therefore, it is essential to ensure equal opportunities and rights for women. Women's empowerment contributes significantly to both economic and social development. When women participate actively in education and employment, the standard of living of families and society improves.

Eradication of poverty and hunger is also closely related to social equity. Poverty deprives people of basic necessities such as food, shelter, education, and healthcare. Therefore, various economic and social policies must be implemented to reduce poverty. True social equity can

be achieved only when all members of society have access to the resources necessary to fulfill their basic needs.

In India, several educational, social, and economic programs are implemented to establish social equity. Various campaigns are conducted to promote universal access to education. Policies related to women's empowerment, social security schemes, healthcare services, and poverty alleviation are also implemented to support weaker sections of society.

Thus, it is clear that social equity is a fundamental requirement for sustainable development. If the benefits of development remain limited to only a few individuals, such development cannot be considered sustainable. Therefore, it is necessary to create a system in which all members of society receive equal opportunities and justice. Through social equity, stability, fairness, and overall development of society can be achieved.

3. Environmental Protection

Environmental protection occupies a very important place in the concept of sustainable development. Environmental protection refers to conserving natural resources on Earth, using them in a balanced and responsible manner, and maintaining ecological balance.

Due to human development activities, industries, cities, transportation systems, and technological infrastructure have expanded rapidly. Although these developments have led to economic growth, they have also caused several environmental problems such as deforestation, pollution, climate change, water scarcity, and loss of biodiversity.

Therefore, protecting the environment has become an urgent necessity.

The main objective of environmental protection is to ensure the long-term and balanced use of natural resources. Resources such as water, air, soil, forests, minerals, and biodiversity are essential for human survival. However, excessive exploitation or mismanagement of these resources can disrupt ecological balance and create scarcity for future generations. Therefore, development must be carried out while ensuring environmental conservation and sustainable resource management.

Protection of biodiversity is an important aspect of environmental conservation. The Earth is home to diverse plants, animals, microorganisms, and ecosystems. These components maintain ecological balance. However, deforestation, pollution, and human interference have pushed many species toward extinction. Loss of biodiversity disturbs ecological balance and ultimately affects human life as well. Therefore, wildlife conservation, protection of natural habitats, and conservation initiatives are essential.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Pollution control is another important component of environmental protection. Industrialization, transportation, chemical usage, and urbanization have significantly increased pollution levels in air, water, and soil. Polluted air, contaminated water, and toxic substances in soil not only harm human health but also damage the environment. Therefore, it is necessary to promote clean energy, manage industrial waste properly, and adopt environmentally friendly technologies.

Water conservation is another crucial aspect of environmental protection. Water is a basic necessity for life, but increasing population, industrialization, and climate change have put tremendous pressure on water resources. Many regions are experiencing severe water shortages. Therefore, proper water management, rainwater harvesting, conservation of rivers, and efficient water usage are essential.

Forest conservation is also essential for maintaining ecological balance. Forests protect biodiversity, prevent soil erosion, regulate rainfall patterns, and control climate conditions. However, human activities have resulted in large-scale deforestation. Therefore, measures such as afforestation, forest conservation, and sustainable forest management are necessary.

Creating environmental awareness among all sections of society is also extremely important for environmental protection. Activities such as tree plantation campaigns, water conservation projects, reducing plastic usage, recycling, and effective waste management can help protect the environment. When citizens actively participate in such initiatives, environmental protection becomes more effective.

Thus, environmental protection is a fundamental pillar of sustainable development. Without protecting the environment, economic and social development cannot remain sustainable. Therefore, it is essential to maintain ecological balance and conserve natural resources at every stage of development. Proper use and conservation of the environment can ensure a safe and prosperous future for coming generations.

Three Pillars of Sustainable Development :-

Sr. No.	Component of Development	Key Elements	Current Status (India – Approximate Data)	Target for Sustainable Development
1	**Economic Development**	Industrial development, employment, technology, production	GDP growth around 7%, more than 100,000 startups, renewable energy about 180 GW	Promotion of green industries, 500 GW renewable energy by 2047, increase in employment

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Sr. No.	Component of Development	Key Elements	Current Status (India – Approximate Data)	Target for Sustainable Development
2	**Social Equity**	Education, healthcare, gender equality, poverty reduction	Literacy rate 77.7%, GER 28–30%, poverty about 10–12%	Education for all, GER 50%, significant reduction in poverty
3	**Environmental Protection**	Biodiversity conservation, pollution control, water conservation	Forest cover about 24%, India ranks third in global CO_2 emissions	33% forest cover, reduction in pollution, expansion of green energy

Source:

1. Government of India. (2023). *Economic Survey of India*. Ministry of Finance.
2. Ministry of Education. (2023). *All India Survey on Higher Education (AISHE) Report*.
3. Forest Survey of India. (2023). *India State of Forest Report*.
4. NITI Aayog. (2023). *National Multidimensional Poverty Index Report*.

From the above data, it is clear that balanced coordination between economic progress, social justice, and environmental protection is essential for sustainable development. If development is limited only to economic growth, it may lead to environmental degradation and increased social inequality. Therefore, for sustainable development, equal emphasis must be given to green technology, inclusive education, and environmental conservation.

India's Vision of Becoming a Developed Nation @2047

The Government of India has set an ambitious goal of transforming India into a developed nation by the centenary year of independence in 2047**.** This vision is often referred to as "Viksit Bharat 2047" or "Vision India 2047." The fundamental objective of this vision is to make India economically strong, socially balanced, technologically advanced, and environmentally sustainable. Achieving this goal requires coordinated and continuous progress across multiple sectors of the country.

The education sector plays a crucial role in the development of India. Education is one of the most important instruments for intellectual and economic advancement in society. Quality and inclusive education enhances individuals' knowledge, skills, and critical thinking abilities. In the modern economy, skilled human resources are highly valued. Therefore, reforms in the education system are necessary to provide students with opportunities in research, innovation, and skill-based learning. Education not only contributes to individual progress but also promotes the economic and social development of the nation.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

The health sector is also extremely important for moving towards the status of a developed nation. Healthy citizens are more productive and can participate more effectively in economic and social development. Therefore, healthcare services must be accessible and affordable for all. Through modern healthcare facilities, medical research, health insurance schemes, and improvements in public health systems, significant progress can be achieved in the country's health sector.

Technological advancement is considered a key driver of progress in the modern world. Development in areas such as digital technology, artificial intelligence, information technology, biotechnology, and space technology enhances the country's production capacity and competitiveness. Technology improves efficiency in various sectors such as industry, education, healthcare, administration, and trade. Hence, technology-driven development is essential for achieving the vision of a developed India.



The industrial sector is regarded as the main engine of a nation's economic development. Industrial growth increases production, creates employment opportunities, and strengthens the national economy. Industrial development can be achieved through the expansion of manufacturing sectors, promotion of small and medium enterprises (SMEs), development of infrastructure, and increased participation in global trade. Industries also enable the efficient utilization of the country's resources and contribute significantly to economic progress.

Research and innovation are also essential components for becoming a developed nation. New technologies, scientific discoveries, and innovations help expand the country's knowledge base and provide effective solutions to various challenges. Research contributes to advancements in agriculture, industrial production, healthcare services, energy, and environmental protection. Collaboration between higher education institutions, research centers, and industries helps develop a strong culture of innovation within the country.

Another important factor in India's development is its large youth population. India possesses one of the largest youth populations in the world, which is considered a significant opportunity for the country. If young people are provided with proper education, skill development, and employment opportunities, they can contribute significantly to economic growth. In economics, this opportunity is referred to as the "Demographic Dividend." Effective utilization of the youth population can increase productivity, generate innovation, and accelerate economic growth.

However, transforming this opportunity into development requires special emphasis on education, skill development, and job creation. When youth are connected with modern technology, research, and industry, they can actively contribute to national progress.

Overall, for India to become a developed nation by 2047, balanced and long-term progress in sectors such as education, healthcare, technology, industry, and research is essential. Coordinated development in these areas will strengthen the national economy, promote social equality, and enable India to emerge as a powerful and advanced nation on the global stage.

Higher Education System in India

India's higher education system is considered one of the largest and most extensive education systems in the world. Due to the country's large population, diversity, and growing demand for knowledge, higher education has gained special importance. Through higher education, students are provided with advanced knowledge in various fields, opportunities for research, and platforms for skill development. This system contributes to the development of human resources in the country and promotes economic, social, and scientific progress.

The higher education system in India includes universities, colleges, research institutions, technical education institutions, and professional education institutions**.** Today, India has more than a thousand universities and thousands of colleges. Millions of students are pursuing education in various disciplines in these institutions. Higher education opportunities are available in fields such as arts, commerce, science, engineering, medical education, management, law, agriculture, and social sciences**.** This extensive educational system provides students with opportunities to build careers in diverse sectors.

Some educational institutions in India are globally recognized for their academic excellence and research contributions. In the field of engineering and technology education, the Indian Institutes of Technology (IITs) hold a prominent position. Students and researchers trained in these institutions have made significant contributions to the global technology sector. In the field of management education, the Indian Institutes of Management (IIMs) have played an important role in providing high-quality education and developing leadership skills. Similarly, in the field of medical education and health research, the All India Institutes of Medical

Sciences (AIIMS) have gained special recognition. In addition, central universities across the country play an important role in various academic and research areas.

To ensure proper regulation and quality control in India's higher education system, several institutions operate at the national level. The University Grants Commission (UGC) is responsible for regulating universities, distributing grants, and setting academic standards in the country. In the field of technical education, the All India Council for Technical Education (AICTE) regulates engineering, management, and other technical programs. Furthermore, the National Assessment and Accreditation Council (NAAC) evaluates the quality of higher education institutions and provides accreditation. These institutions help maintain transparency, quality, and accountability within the higher education system.

Research and innovation are also receiving increasing importance in India's higher education system. In the modern knowledge-based economy, research and innovation are considered key drivers of progress. Therefore, many universities and research institutions are actively engaged in research on various scientific, technological, and social issues. Such research activities contribute to the development of new technologies, scientific discoveries, and effective solutions to social challenges.

However, the higher education system in India also faces several challenges. Issues such as the quality of education, funding for research, infrastructure, and teacher training need further improvement. To address these challenges, the government has implemented various policies and programs. Through the National Education Policy (NEP), efforts are being made to promote quality education, research, skill development, and international collaboration within the education system.

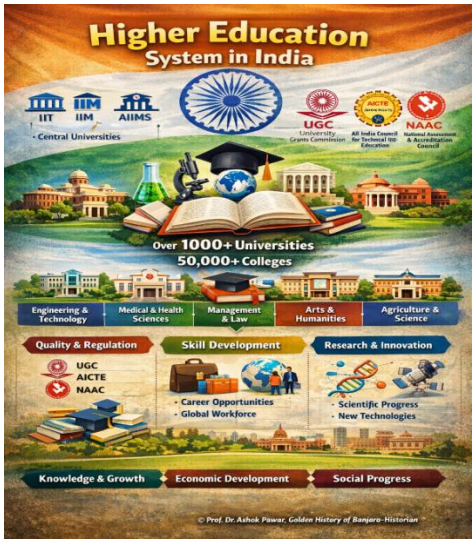
Overall, the higher education system in India plays a vital role in the country's overall development. It helps in creating a skilled workforce, promotes research activities, and contributes to both social and economic progress. If the quality and effectiveness of this system are further strengthened in the future, India can emerge more strongly as a global knowledge-based nation.

Role of Higher Education in Development

Higher education plays a crucial role in the overall development of any nation. It not only promotes the dissemination of knowledge but also prepares the skilled human resources required for economic, social, scientific, and technological progress. In a modern knowledge-based society, universities and higher education institutions are not merely centers for teaching but also hubs for research, innovation, and social transformation. Therefore, higher education is considered one of the fundamental pillars of national development.

The first and most significant impact of higher education can be seen in human resource development**.** Education enhances individuals' knowledge, skills, and intellectual capabilities. Universities and colleges produce experts, scientists, engineers, doctors, managers, and researchers in various fields. These skilled professionals contribute to different sectors of the economy and help accelerate economic and social development. Thus, higher education is regarded as an effective instrument for human resource development. The higher the quality and accessibility of education, the stronger a nation's development becomes.

Another important role of higher education institutions is the promotion of research and innovation**.** Universities and research institutions conduct studies on various scientific, technological, and social issues, generating new knowledge. Through such research, new technologies, innovations, and modern solutions are developed. For instance, significant advancements in fields such as information technology, biotechnology, medical research, environmental science, and energy have largely been made possible through university-based research. Research and innovation help address various social problems and contribute to scientific progress within the country.

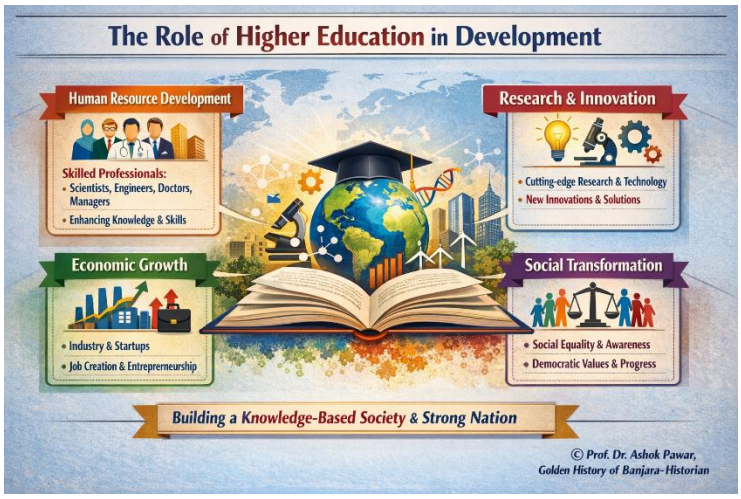


Higher education also has a significant impact on economic development. It creates skilled and trained human resources that are essential for the growth of industry, technology, and the service sector. Higher education encourages entrepreneurship and leads to the establishment of new businesses and startups. Many technology companies and industries are based on ideas and research developed within universities. As a result, higher education institutions contribute to job creation and strengthen the national economy.

Higher education also plays an important role in bringing about positive social transformation. Education fosters awareness, critical thinking, and a sense of social responsibility among individuals. It helps reduce superstition, social discrimination, and inequality in society.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Furthermore, education promotes democratic values, awareness of human rights, and a sense of social equality among citizens. In this way, education helps build a more progressive, informed, and balanced society.



From the above discussion, it is clear that higher education is essential not only for individual advancement but also for the development of society and the nation as a whole. Higher education significantly contributes to human resource development, research and innovation, economic growth, and social transformation. Therefore, improving the quality and effectiveness of the higher education system is extremely important for the progress of the nation.

National Education Policy 2020 (NEP 2020)

The National Education Policy 2020 (NEP 2020) is considered one of the most significant and comprehensive reform policies in India's education sector. After nearly three decades, India has adopted such a major policy aimed at transforming the education system. Earlier, the National Education Policy of 1986 was introduced, after which several changes took place in the education system. However, due to changing global conditions, rapid technological advancements, and the evolving needs of the modern knowledge economy, the need for a new education policy became evident. In this context, the Government of India began implementing the National Education Policy 2020.

The main objective of NEP 2020 is to make India's education system more modern, flexible, inclusive, and quality-oriented. The policy emphasizes developing students' creativity, research orientation, critical thinking, and skills. Rather than focusing solely on rote learning, the policy promotes a system that encourages the holistic development of students.

One of the most important features of this policy is the concept of multidisciplinary education. In the traditional education system, students usually studied within a specific discipline.

However, under the new policy, students are given the opportunity to study a combination of subjects from different fields. For example, a student studying science may also choose subjects from arts or social sciences. This approach helps develop a broader perspective among students and enhances their creativity and problem-solving abilities.



The policy also places special emphasis on research and innovation. Various measures have been proposed to promote a strong research culture in higher education institutions. The policy expects universities and research institutions in India to become more active in generating new knowledge, scientific discoveries, and innovations. Encouraging research can significantly accelerate the country's technological and scientific progress.

The expansion of digital education is another important component of NEP 2020. With the increasing importance of information technology in modern times, the policy emphasizes the integration of digital tools into the education system. Efforts are being made to provide more effective and accessible education through online learning, digital learning materials, virtual laboratories, and e-learning platforms**.** Digital technologies can make education more accessible, flexible, and widespread.

Another key objective of this policy is to increase the number of students enrolling in higher education. For this purpose, the policy aims to increase the Gross Enrollment Ratio (GER) in higher education to about 50 percent by 2035**.** This means that providing greater access to higher education opportunities for a larger number of students is a major focus of the policy. By promoting inclusiveness in education, the policy seeks to bring various sections of society into the mainstream of higher education.

The National Education Policy 2020 is considered an important step toward making India's education system globally competitive. Through this policy, emphasis is placed on improving the quality of education, strengthening research, enhancing skill development, and increasing the use of technology in education. From a long-term perspective, this policy can play a crucial role in India's social, economic, and intellectual development**.**

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Implementation of NEP 2020 in Maharashtra State – Numerical Data

Sr. No.	Component	Data (Maharashtra)	Percentage / Observation
1	Total Universities in the State	75	100% base
2	Universities Implementing NEP	24	Implementation started in **32% universities**
3	Total Colleges in the State	7,000	—
4	Colleges Implementing NEP Curriculum	1,100	15.7% colleges **implementing NEP**
5	Technical Institutions (Polytechnic)	350	Increase in **skill-based courses**
6	Total Students in Higher Education	4,800,000	Total number of students in Maharashtra
7	Students Benefiting from NEP Curriculum	1,200,000	Around **25% students**
8	Students Using Digital Education	3,000,000	Around **62% students**
9	Skill-Based Courses Introduced	1,000+	Growth in **employment-oriented education**
10	Gross Enrollment Ratio (GER)	35%	Higher than the **national average**

Source :-

1. Government of Maharashtra. (2023). *Higher and Technical Education Department Annual Report*. Mumbai.
2. Ministry of Education, Government of India. (2023). *All India Survey on Higher Education (AISHE) Report 2021–22*. New Delhi.
3. Government of Maharashtra. (2023). *Implementation Report of National Education Policy (NEP 2020) in Maharashtra Universities*.

4. University Grants Commission (UGC). (2023). *Higher Education Statistics in India*. New Delhi.
5. Directorate of Higher Education, Maharashtra. (2023). *Statistical Handbook of Higher Education in Maharashtra*.

Benefits of NEP 2020 for Students

Sr. No.	Component	Before NEP	After NEP
1	Duration of Undergraduate Program	3 Years	4 Years (with **Research Option**)
2	Subject Selection	1 Major Subject	2–3 **Multidisciplinary Subjects**
3	Research Projects	Up to **10% students**	Up to **35% students**
4	Use of Digital Learning	**25% students**	**62% students**
5	Skill Training	**15% students**	**45% students**
6	Industry Internships	**12% students**	**40% students**

Source :-

1. Government of India. (2020). *National Education Policy 2020*. Ministry of Education.
2. Ministry of Education. (2023). *All India Survey on Higher Education (AISHE) Report*.
3. Association of Indian Universities (AIU). (2022). *Preparedness of Higher Education Institutions for Online Education Report*.
4. University Grants Commission (UGC). (2023). *Guidelines for Four-Year Undergraduate Programme (FYUGP) and Multidisciplinary Education*.

From the above data, it can be observed that the implementation of NEP 2020 in Maharashtra has gradually begun on a large scale. Many universities in the state have introduced reforms such as the Four-Year Undergraduate Programme (FYUGP), multidisciplinary curriculum, and the Academic Bank of Credits (ABC). These reforms provide students with greater flexibility in choosing subjects according to their interests and offer opportunities to engage in research.

The expansion of digital education has also enabled students from rural and remote areas to access online learning, e-libraries, and virtual laboratories. Additionally, skill-based courses are helping improve students' employability.

Industry-linked training, internships, and project-based learning are making education more practical and career-oriented. Overall, the implementation of NEP 2020 in Maharashtra is promoting flexibility, quality education, and skill development within the higher education system. If implemented effectively in the future, this policy has the potential to significantly enhance students' knowledge, skills, and research capabilities.

Challenges in the Higher Education Sector

Although India's higher education system is one of the largest in the world, it faces several serious challenges. While the expansion of education has taken place on a large scale, there is still a need for significant improvements in areas such as the quality of education, research standards, infrastructure, and skill development. These challenges affect not only the education system but also the country's economic and social development. Therefore, it is necessary to analyze these issues carefully and implement appropriate measures to address them.

One of the major challenges in the higher education sector is the lack of quality in education. In many universities and colleges, the standard of education does not meet the expected level. Outdated curricula, limited use of modern technology, insufficient emphasis on research, and limitations in teaching methods prevent students from acquiring the modern knowledge and skills required in today's world. As a result, many students face difficulties in securing employment opportunities. Therefore, improving the quality of education has become an urgent necessity.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal



Another important challenge is the lack of adequate funding for research. In a modern knowledge-based economy, research and innovation play a crucial role. However, many universities and research institutions in India are unable to conduct effective research due to insufficient financial resources. The lack of research laboratories, modern equipment, and technical facilities limits both the quality and quantity of research. Hence, it is necessary to increase funding for research and promote a strong research culture in higher education institutions.

The lack of skill development is also a significant issue in the higher education sector. In many cases, the education system focuses more on theoretical knowledge, while practical skills required for industry and employment are not sufficiently developed among students. Consequently, many graduates find it difficult to obtain suitable employment after completing their education. Strengthening the connection between education and industry and providing skill-based education is therefore essential.

The shortage of qualified teachers is another serious problem. Many universities and colleges have vacant positions for professors and teaching staff. The lack of experienced and well-trained teachers negatively affects the quality of education. Providing proper teacher training, encouraging research activities, and ensuring appropriate salary structures can help improve the overall quality of education.

Limited access to higher education in rural and remote areas is also an important challenge. While many reputed educational institutions are located in urban areas, students in rural regions often lack access to quality educational facilities. Due to inadequate infrastructure, financial

constraints, and lack of information, many students find it difficult to pursue higher education. Therefore, it is necessary to expand educational facilities in rural areas and promote digital education.

Overall, although India's higher education system has expanded significantly, it still faces several challenges. Improving the quality of education, increasing funding for research, promoting skill development, ensuring the availability of qualified teachers, and expanding educational opportunities in rural areas are essential steps. Addressing these issues will make the higher education system more effective and capable, thereby accelerating the country's social, economic, and scientific development.

Reforms Required for 2047

India has set a goal of becoming a developed nation by 2047. To achieve this objective, it is essential to implement comprehensive and effective reforms in the country's education system, particularly in the higher education sector. In a modern knowledge-based economy, education, research, technology, and skill development play a crucial role. Therefore, strengthening the higher education system and making it more efficient, high-quality, and globally competitive has become a necessity.

For India's development, research and innovation must be given special priority. In the modern world, scientific research and technological advancement are considered key drivers of economic and social development. Therefore, universities and research institutions must receive greater financial support. Adequate funding for research will help develop modern laboratories, advanced technical equipment, and research facilities. This will encourage scientific discoveries, the development of new technologies, and innovative solutions. Increasing both the quality and quantity of research can significantly accelerate the country's industrial, technological, and scientific progress.

Another important reform is the development of world-class universities in India. In today's globally competitive environment, the quality of educational institutions and their research capacity are extremely important. Although some Indian institutions are internationally recognized, it is necessary for more universities to achieve global standards. This requires improvements in infrastructure, recruitment of high-quality faculty, modernization of curricula, and encouragement of research activities. Establishing world-class universities will provide excellent educational opportunities for Indian students and also attract international students to pursue education in India.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal



Strengthening the collaboration between industry and education is also a major requirement. Often, there is a gap between the knowledge provided in educational institutions and the skills required by industries. Therefore, universities should enhance cooperation with industry to provide students with practical knowledge and experience. Industry-related projects, internships, training programs, and collaborative research initiatives can help make students more capable and employment-ready.

The expansion of digital education is another important aspect of the future education system. With the rapid advancement of information technology, the methods of education are changing significantly. Online learning, digital learning materials, virtual laboratories, and e-learning platforms can make education more accessible and widespread. Digital education can be especially beneficial for students in rural and remote areas. Therefore, it is necessary to strengthen digital infrastructure and promote technology-based education.

Emphasizing skill-based education is also an essential reform. In the modern job market, theoretical knowledge alone is not sufficient; practical skills and technical competencies are equally important. Therefore, students must be provided with special training to develop the skills required for industry and service sectors. Skill-based education enhances students' employability and also encourages entrepreneurship.

Required Reforms in the Higher Education Sector for 2047

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Sr. No.	Reform Area	Current Status (India)	Target for 2047	Expected Outcome
1	Research Funding (R&D Expenditure)	Around **0.7% of GDP**	**2–3% of GDP**	Increase in research, innovation, and scientific discoveries
2	World-Class Universities	**10–12 Indian universities** in Top-500	**50+ world-class universities**	Stronger global position of India in higher education
3	Industry–Education Collaboration	About **25% courses linked with industry**	**70% courses industry-integrated**	Increase in employability and startups
4	Digital Education	About **60% students use e-learning**	**100% digital education access**	Reduction in rural–urban education gap
5	Skill-Based Education	Around **30% students receive skill training**	**80% students receive skill training**	Growth in employment and entrepreneurship
6	Gross Enrollment Ratio (GER) in Higher Education	Around **28–30%**	**50%+**	More students gain access to higher education
7	Research Institutions	About **1500+ major research institutions**	**3000+ research institutions**	Strengthening of a knowledge-based economy
8	Startups and Innovation	**100,000+ startups**	**500,000+ startups**	Economic growth and job creation
9	Technology-Based Education	Limited **AI/Data Science courses**	**AI, Robotics, and Data Science in all universities**	Global leadership in technology sectors
10	International Students	About **50,000 foreign students**	**500,000+ foreign students**	India becomes a global education hub

Source :-

1. Government of India. (2020). *National Education Policy (NEP) 2020*. Ministry of Education.
2. Ministry of Education. (2023). *All India Survey on Higher Education (AISHE) Report*.
3. Government of India. (2023). *Economic Survey of India*. Ministry of Finance.
4. NITI Aayog. (2023). *India Innovation Index Report*.
5. Department for Promotion of Industry and Internal Trade (DPIIT). (2023). *Startup India Report*.
6. UNESCO Institute for Statistics. (2022). *Global Education Monitoring Data*.
7. University Grants Commission (UGC). (2023). *Higher Education Statistics and Policy Guidelines*.

Overall, for India to become a **developed nation by 2047**, it is essential to implement comprehensive reforms in the education system. Measures such as increasing funding for research, establishing world-class universities, strengthening collaboration between industry and education, expanding digital education, and promoting skill-based learning can make the higher education system more effective and robust. If these reforms are implemented efficiently, they can significantly accelerate India's economic, social, and scientific development and enable the country to move firmly toward the goal of becoming a developed nation.

Conclusion

The concept of sustainable development is extremely important from the perspective of India's development. Long-term and stable development of any nation can only be achieved by maintaining a balance among economic progress, social equity, and environmental protection. India has set the goal of becoming a developed nation by 2047, and to achieve this objective, the country's education system—particularly higher education—will have to play a crucial role. In a modern knowledge-based economy, education, research, and technology are considered the key pillars of development. Therefore, it has become essential to make the higher education system stronger, more qualitative, and research-oriented.

India's higher education system is one of the largest in the world and contributes significantly to the development of the country's human resources. Through universities, research institutions, and technical education centers, skilled manpower is being developed across the country. This skilled workforce contributes to progress in sectors such as industry, technology, healthcare, administration, and social development. Higher education helps develop knowledge, skills, innovation, and a research-oriented mindset among students. Thus, the higher education system is not merely a mechanism for providing education but has become a powerful instrument for the economic and social transformation of the nation.

Furthermore, India's youth population plays a vital role in the country's development. Since India possesses one of the largest youth populations in the world, it can become a significant "demographic dividend" for the nation. However, to effectively utilize this opportunity, it is necessary to provide young people with quality education, skill training, and research opportunities. If the education system prioritizes quality, innovation, and skill development, this youthful energy can contribute greatly to the country's economic and technological advancement.

The National Education Policy 2020 (NEP 2020) is an important step toward bringing comprehensive reforms to India's education system. Through this policy, emphasis has been placed on multidisciplinary education, promotion of research, expansion of digital learning, and increasing access to higher education. If these reforms are implemented effectively, India's education system can become more modern, flexible, and globally competitive.

However, India's higher education system also faces several serious challenges. Issues such as the quality of education, inadequate funding for research, lack of skill development, shortage of teachers, and limited educational facilities in rural areas still persist. Without addressing these problems effectively, the full potential of the higher education system cannot be realized. Therefore, it is necessary to increase investment in education, expand financial support for research, strengthen collaboration between industry and education, and promote the widespread use of digital technologies.

To transform India into a developed nation by 2047, the higher education system must become more research-oriented, skill-based, and innovation-driven. Special attention should be given to establishing world-class universities, connecting students with modern technologies and industries, and improving inclusiveness and quality in education. With proper coordination among education, research, and technology, India's economy can become stronger and the country can play a significant role on the global stage.

Overall, higher education is a crucial link in achieving the vision of sustainable development. Through education, society can develop knowledge, equality, innovation, and awareness about environmental protection. By improving the quality of higher education and promoting research, India can realize its dream of becoming a developed and sustainable nation by 2047.

References :-

1) Ministry of Education, Government of India. (2020). National Education Policy 2020. Government of India.
2) United Nations. (2015). Transforming our world: The 2030 agenda for sustainable development. United Nations.

3) World Commission on Environment and Development. (1987). Our common future. Oxford University Press.
4) Tilak, J. B. G. (2018). Higher education in India: In search of equality, quality and quantity. Orient BlackSwan.
5) Altbach, P. G., & Salmi, J. (2011). The road to academic excellence: The making of world-class research universities. World Bank.
6) Agarwal, P. (2009). Indian higher education: Envisioning the future. Sage Publications.
7) Varghese, N. V. (2015). Challenges of higher education in India. UNESCO International Institute for Educational Planning.
8) Government of India. (2021). Economic Survey of India 2020–21. Ministry of Finance.
9) Planning Commission of India. (2013). Twelfth Five Year Plan (2012–2017): Faster, sustainable and more inclusive growth. Government of India.
10) World Bank. (2020). World development report 2020: Trading for development in the age of global value chains. World Bank.
11) UNESCO. (2021). Education for sustainable development: A roadmap. UNESCO Publishing.
12) University Grants Commission. (2022). Annual report 2021–22. UGC.
13) All India Council for Technical Education. (2022). AICTE annual report 2021–22. AICTE.
14) National Institution for Transforming India (NITI Aayog). (2023). SDG India index and dashboard 2023. Government of India.
15) Gupta, D., & Gupta, N. (2012). Higher education in India: Structure, statistics and challenges. Journal of Education and Practice, 3(2), 17–24.
16) OECD. (2019). Education at a glance 2019: OECD indicators. OECD Publishing.
17) Ministry of Statistics and Programme Implementation. (2022). India statistical yearbook 2022. Government of India.
18) World Economic Forum. (2022). The future of jobs report 2022. World Economic Forum.
19) United Nations Development Programme. (2023). Human development report 2023. UNDP.
20) NITI Aayog. (2022). India's vision for developed nation by 2047. Government of India.
21) Tilak, J. B. G. (2015). Higher education and development in India. Journal of Asian Public Policy, 8(1), 49–64.
22) UNESCO. (2020). Global education monitoring report 2020: Inclusion and education. UNESCO.
23) Altbach, P. G., Reisberg, L., & Rumbley, L. (2010). Trends in global higher education: Tracking an academic revolution. UNESCO.
24) Government of Maharashtra. (2023). Higher and technical education department report. Government of Maharashtra.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

EDUCATION FOR SUSTAINABLE DEVELOPMENT

Mr. Kokare Krishna Vitthal
Asst. Prof. Dept. of Economics
Mula Education Societies, Arts, Commerce and Science College, Sonai
Tal- Newasa, Dist.- Ahilyanagar (Maharashtra)
Email - krishnakv3225@gamil.com

Abstract:

Education for Sustainable Development (ESD) has emerged as a key strategy for addressing global environmental, social, and economic challenges. Rapid industrialization, climate change, population growth, and the overexploitation of natural resources have created serious threats to environmental sustainability. Sustainable development focuses on meeting present needs without compromising the ability of future generations to meet their own needs. Global organizations such as the United Nations and the United Nations Educational, Scientific and Cultural Organization emphasize integrating sustainability principles into education systems worldwide. Education helps students develop environmental awareness, critical thinking, and responsible decision-making regarding natural resources. This study examines the role of education in promoting sustainable development among students. The research uses a secondary research method supported by statistical analysis of survey data collected from 50 students. The findings reveal that education significantly increases awareness about sustainability and encourages participation in environmental protection activities such as tree plantation, water conservation, and cleanliness campaigns. The study concludes that incorporating sustainability concepts into educational curricula and institutional activities can foster environmentally responsible citizens and contribute to sustainable development.

Key Words

Education for Sustainable Development, Sustainability, Environmental Education, Environmental Awareness, Sustainable Development Goals

Introduction

Environmental issues have become one of the most pressing challenges of the modern world. Rapid industrialization, urban expansion, deforestation, and the excessive use of natural resources have led to environmental degradation and climate change. These issues threaten biodiversity, human health, and the sustainability of ecosystems.

To address these problems, the concept of sustainable development was introduced. Sustainable development promotes balanced development that integrates economic growth, social equality, and environmental protection. According to the United Nations, sustainable development aims to meet the needs of the present generation without compromising the ability of future generations to meet their needs.

plays a vital role in achieving sustainability goals. The United Nations Educational, Scientific and Cultural Organization introduced the concept of **Education for Sustainable Development (ESD)** to empower learners with the knowledge, values, and skills required to contribute to a sustainable future.

Education for Sustainable Development helps students understand environmental issues, develop responsible attitudes, and actively participate in sustainable practices such as conservation, waste management, and sustainable consumption. Educational institutions therefore play a crucial role in promoting sustainability through curriculum integration and environmental activities.

Objectives of the Study

1. To understand the concept of Education for Sustainable Development.
2. To examine the role of education in promoting environmental awareness.
3. To analyse students' participation in environmental protection activities.
4. To evaluate the effectiveness of educational initiatives in promoting sustainable behaviour.

Hypothesis

1. Education significantly increases awareness about sustainable development among students.
2. Environmental education positively influences students' attitudes and participation in environmental protection activities.

Research Methodology

Research Method

The present study is based on **Secondary Research Methods** combined with descriptive statistical analysis.

Sources of Data

Secondary Data

Secondary data were collected from:

- Books related to environmental education
- Research articles and academic journals
- International organization reports

- Government publications
- Online educational resources

Sample Framework (Supporting Data)

Statistical data for analysis were derived from survey responses of **50 students** collected through educational studies and environmental awareness reports.

Statistical Methods Used

- Percentage analysis
- Tabular analysis
- Graphical representation (Bar chart and Pie chart)
- Descriptive interpretation

Review of Literature (Stronger Research Perspective)

Research on Education for Sustainable Development highlights the importance of integrating sustainability concepts into educational systems.

Gro Harlem Brundtland (1987) in the report **Our Common Future** introduced the concept of sustainable development and emphasized the need for responsible resource management.

The United Nations Educational, Scientific and Cultural Organization has consistently promoted Education for Sustainable Development as a tool to develop critical thinking, environmental responsibility, and sustainable lifestyles among learners.

Stephen Sterling (2001) argued that education systems must move beyond traditional knowledge delivery and adopt transformative learning approaches that encourage ecological awareness and sustainable thinking.

Charles Hopkins and **Rosalyn McKeown emphasized that environmental education programs in schools significantly improve students' environmental knowledge and participation in sustainability initiatives.

Research published in the *Journal of Environmental Education* indicates that students exposed to environmental education programs show higher levels of ecological awareness and engagement in sustainability practices.

These studies demonstrate that education is a powerful instrument for achieving sustainable development and promoting environmental responsibility among young learners.

Data Analysis and Statistical Interpretation

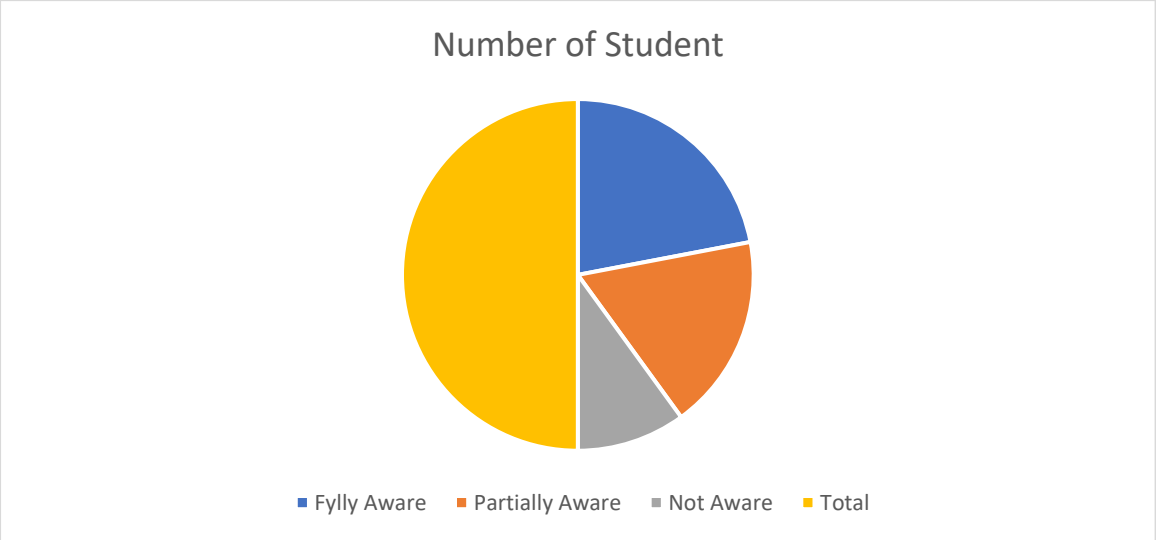
Table 1

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Students' Awareness about Sustainable Development

Sr. No.	Awareness Level	Number of Student	Percentage
1	Fully Aware	22	44
2	Partially Aware	18	36
3	Not Aware	10	20
Total		50	100

Graph Representation



Interpretation:

- Nearly half of the students (44%) have full awareness of sustainable development.
- 36% possess partial awareness.
- 20% lack awareness.

This indicates that educational exposure plays a significant role in developing sustainability awareness.

Table 2

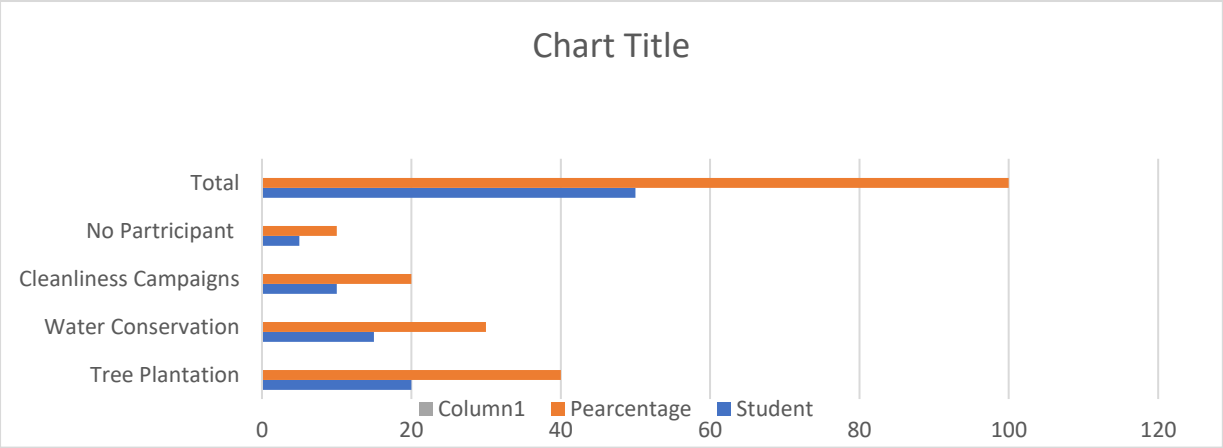
Participation in Environmental Activities

Sr. No.	Activity	Student	Percentage
	Tree Plantation	20	40
	Water Conservation	15	30
	Cleanliness Campaigns	10	20

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

	No Participation	5	10
Total		**50**	**100**

Graph Representation



Interpretation:
The majority of students actively participate in environmental protection activities, particularly tree plantation and water conservation. Only a small percentage do not participate in such activities.

Statistical Analysis

The percentage method was used to interpret the collected data.

Formula:

Percentage = (Number of responses / Total responses) × 100

Example:

Awareness

Percentage
= (22 / 50) × 100
= 44%

The statistical findings support the hypothesis that education positively influences environmental awareness and participation in sustainability activities.

Conclusion

The study highlights the crucial role of education in promoting sustainable development. Education helps students understand environmental issues, develop responsible attitudes, and participate in activities that protect natural resources.

The statistical findings indicate that a majority of students are aware of sustainable development and actively participate in environmental activities such as tree plantation and water conservation.

Educational institutions should strengthen sustainability education by integrating environmental topics into the curriculum, organizing environmental awareness programs, and encouraging students to adopt sustainable lifestyles.

Education for Sustainable Development is therefore essential for building environmentally responsible citizens and achieving global sustainability goals.

References

Books

- Stephen Sterling (2001). *Sustainable Education: Re-visioning Learning and Change*.
- Charles Hopkins & Rosalyn McKeown (2002). *Education for Sustainable Development Toolkit*.

Articles and Journals

- Journal of Environmental Education Research
- International Journal of Sustainability in Higher Education

Reports

- Our Common Future
- United Nations Sustainable Development Goals Report

Websites

- United Nations – https://www.un.org
- United Nations Educational, Scientific and Cultural Organization – https://www.unesco.org

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

A STUDY ON SUSTAINABLE DEVELOPMENT THROUGH EDUCATION: OPPORTUNITIES AND CHALLENGES

Seema Badiger
M.Com. II year, Student,
Department of PG Studies and Research in Commerce,
Rani Channamma University, Belagavi.
Contact No.: 8792729496
Email id: seemabadiger1512@gmail.com

Abstract:

In order to solve social, economic and environmental issues, sustainable development has emerged as a global concern. Educating people with the abilities, attitudes and values are required to create a sustainable future, education plays a vital role in encouraging Sustainable Development (SD). Combining sustainability ideas into teaching and learning process is a key component of the Sustainable Development (SD) through education. This paper explores the concept of education in Sustainable Development (SD); the opportunities and challenges faced in integrating sustainability in curriculum. This particular research is based on secondary data such as various articles and online sources. This study resulted that education can merely promote environmental awareness among the individuals and therefore it is suggested to strengthen Sustainable Development (SD) through education.

Keywords: *Education, Sustainable Development, Sustainability*

Introduction

In the 21st century, one of the most important global goals is sustainable development. Rapid increase in industrialisation, depletion of natural resources and change in climatic conditions have raised the concerns over the sustainability. Due to these concerns sustainable development has emerged and is gaining its importance. Sustainable Development states that it is the development that meets the needs of the present generation as well as aims to preserve the resources for the future generations. Thus, education has a vital role to play in creating awareness and promoting responsible action towards the environment and society.

Sustainable Development through Education aims to enable individuals with knowledge and skills required to address the challenges of sustainability. It motivates problem solving, critical thinking and participation in sustainable practices. Through educating individuals' awareness of environmental protection and sustainability can be created. Educational institution has the capacity to promote sustainable development practices among students and society.

Moreover, despite increasing sustainable development awareness still education institutions face difficulties in integrating sustainable development concepts in the curriculum. Therefore, it is very crucial to examine both the opportunities and challenges that are linked with sustainable development through education.

Literature Review

J Suresh Kumar & D Shobana (2023) in their study aimed on strategies and challenges of sustainable development policies in India and investigates the multifaceted aspects of sustainable development within the country. It also aimed to understand the various strategies that were employed and the obstacles faced in pursuing a sustainable development agenda. The data was collected from online papers, journals and other relevant sources. It was found that the governance of India faced challenges and obstacles that hinder the effective execution of sustainable development policies.

Kioupi & Voulvoulis (2022) in their work aimed to provide information to educational institution and community stakeholders about the Sustainable Development (SD) through Education and actions that they can incorporate to their own needs and circumstances. This research was carried out between 2018 and 2020 to make the educational communities to develop visions around SDG. 3 case studies were performed to evaluate the sustainability among the learners of university and 2 schools in the UK.

Wu & Shen (2016) this study provided a understanding of academic research into higher education for Sustainability Development(SD). The data was reviewed from four scientific literature databases. The study resulted that the research trends had no link with UNESCO'S viewpoint and that researchers focused on popular events which lead to the difference between the number of articles in each year. The findings resulted that most of researches were based on environmental issues and hence the need for the integration of higher education and Sustainable Development was pointed.

Dale & Newman (2005) The main purpose of this study was to differentiate environmental education from sustainable development education and emphasized problem based interdisciplinary learning to sustainable development education. This study was based on secondary data where the works that were published which linked to sustainability development through education were collected and analysed. The study results in the requirement of complex interdisciplinary approach of sustainability and development which was not found in many areas of conventional environmental education.

Objectives

1. To understand the concept of sustainable development (SD) in education.
2. To identify the opportunities of sustainable development throughs education.
3. To investigate the challenges faced in integrating sustainable development in curriculum.

Methodology

The study is descriptive and is based on the secondary source of data. Data has been taken from multiple secondary sources such as articles, websites and online sources.

Concept of Sustainable Development (SD) and Education

According to UNESCO, "Education for Sustainable Development empowers people with the knowledge, skills, values, attitudes and behaviours to live in a way that is good for the environment, economy and society. It encourages people to make smart, responsible choices that help create a better future for everyone".

Majorly there are three pillars on which Sustainable development is based on namely- environment protection, economic development, and social equity. Creating awareness about environmental conservation is what education in sustainable development contributes to.

UNESCO's Education to Sustainable Development (ESD) for 2030 programme is creating and sharing knowledge, giving guidance and technical support to the various countries, that helps them to implement the projects. It promotes peer learning and creative ideas through information, networks and partnerships.

Opportunities of Sustainable Development (SD) through Education

Promotion of Environmental Awareness: By educating individuals about sustainability, individuals become more responsible towards environment. Creating awareness helps individuals comprehend environmental problems such as pollution, change in climatic conditions and reduction in resources.

Development of Sustainable Skills and Values: Education encourages critical-thinking, ability to take decision and problem-solving skills among individuals that are essential for tackling sustainability challenges.

Responsible Citizenship: Through the integration of education in sustainable development, individuals learn about their social responsibility, equality and ethical values which will help to build sustainable communities.

Contribution to Sustainable Practices: Combining of sustainability into education creates awareness and leads to the sustainable practices such as energy conservation and management of the waste. This contributes in achieving the SDGs.

Challenges in integrating Sustainability in Education

Rigid curricula: Integrating sustainability in education is challenging due to the rigidity of the traditional education system. Traditional education is based on test and is scheduled with theoretical aspects which lacks flexibility that is needed for interdisciplinary demanded by ESD.

Lack of resources and training: In order to incorporate ESD successfully resources like financial assets and teachers are required which most of the institutions lack.

Limited awareness: In many educational institutions sustainability development is not strongly integrated which results into the students graduating without the awareness of sustainability and responsibilities towards protection and conservation of natural resources.

Low community participation: Due to lack of knowledge or desire, many communities do not actively participate in sustainability projects like waste management, conservation programs, sustainable packaging, green logistics.

Conclusion

Education plays a crucial role in raising awareness, fostering responsible behaviour and developing skills, in achieving sustainability. It gives people the chance to understand and face issues related to global sustainability. However, overcoming obstacles including ignorance and poor curricular integration is essential for the effective implementation of education for SD. Thus, it is suggested to make a strong integration of SD in the curriculum for a brighter future for the future generations.

References

Corcoran, P. B., Calder, W., & Clugston, R. M. (2002). Introduction: Higher education for sustainable development. *Higher Education Policy*, *15*(2), 99–103. https://doi.org/10.1016/S0952-8733(02)00009-0

Dale, A., & Newman, L. (2005). Sustainable development, education and literacy. *International Journal of Sustainability in Higher Education*, *6*(4), 351–362. https://doi.org/10.1108/14676370510623847

GLOBAL-UNIVERSITY-NETWORK-FOR-INNOVATION-12023 (pg 47). (n.d.).

Henderson, K., & Loreau, M. (2023). A model of Sustainable Development Goals: Challenges and opportunities in promoting human well-being and environmental sustainability. *Ecological Modelling*, *475*, 110164. https://doi.org/10.1016/j.ecolmodel.2022.110164

Kahn, R. (2008). Introduction. *Green Theory & Praxis: The Journal of Ecopedagogy*, *4*(1), i–iv. https://doi.org/10.3903/gtp.2008.1.1

Kioupi, V., & Voulvoulis, N. (2022). Education for Sustainable Development as the Catalyst for Local Transitions Toward the Sustainable Development Goals. *Frontiers in Sustainability*, *3*, 889904. https://doi.org/10.3389/frsus.2022.889904

Kopnina, H., & Meijers, F. (2014). Education for sustainable development (ESD): Exploring theoretical and practical challenges. *International Journal of Sustainability in Higher Education*, *15*(2), 188–207. https://doi.org/10.1108/IJSHE-07-2012-0059

Kumar, Dr. J. S., & D., S. (2023). A STUDY ON STRATEGIES AND CHALLENGES OF SUSTAINABLE DEVELOPMENT POLICY IN INDIA. *International Journal of Social Sciences & Economic Environment*, *8*(2), 67–81. https://doi.org/10.53882/IJSSEE.2023.0802005

Laurie, R., Nonoyama-Tarumi, Y., Mckeown, R., & Hopkins, C. (2016). Contributions of Education for Sustainable Development (ESD) to Quality Education: A Synthesis of Research. *Journal of Education for Sustainable Development*, *10*(2), 226–242. https://doi.org/10.1177/0973408216661442

Mohanty, A., & Dash, D. (2018). *Education for sustainable development: A conceptual model of sustainable education for India*.

Mundhe, D. E. (n.d.). *SUSTAINABLE DEVELOPMENT*.

Sen, D. V., & Malhotra, N. (2025). *A Critical Analysis of the Education for Sustainable Development*. *3*(1).

Tafese, M. B., & Kopp, E. (2025). Education for sustainable development: Analyzing research trends in higher education for sustainable development goals through bibliometric analysis. *Discover Sustainability*, *6*(1), 51. https://doi.org/10.1007/s43621-024-00711-7

Wan Nor Azmi, W. N. A., Abd Wahid, N. H., Syed Azman, S. M., & Jayus, R. (2024). Integrating Sustainability into Curricula: A Systematic Review of Education for Sustainable Development. *E-Bangi Journal of Social Science and Humanities*, *20*(4). https://doi.org/10.17576/ebangi.2024.2104.09

Webb, S., Holford, J., Hodge, S., Milana, M., & Waller, R. (2019). Conceptualising lifelong learning for sustainable development and education 2030. *International Journal of Lifelong Education*, *38*(3), 237–240. https://doi.org/10.1080/02601370.2019.1635353

Wu, Y.-C. J., & Shen, J.-P. (2016). Higher education for sustainable development: A systematic review. *International Journal of Sustainability in Higher Education*, *17*(5), 633–651. https://doi.org/10.1108/IJSHE-01-2015-0004

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

PEDAGOGICAL INNOVATIONS IN HIGHER EDUCATION FOR SUSTAINABLE MSME DEVELOPMENT

Sharad J Bikkannavar
Research scholar
Rani Channamma Universtiy, Belagavi
Mob: 8660853778, Email: sharadbknvr@gmail.com

Abstract

This study examines how pedagogical innovations in Indian higher education can support the development of Micro, Small and Medium Enterprises (MSMEs). MSMEs contribute roughly 30% of India's GDP and 45% of its exports, yet a large share of them struggle to remain competitive, adopt new technologies, or build lasting management capacity. The question this research addresses is whether universities can help — and if so, through what specific approaches.

The study draws on case studies from eight institutions across India and surveys of 420 students, supplemented by 56 interviews and six focus group discussions with MSME entrepreneurs. The findings indicate that experiential learning, digital pedagogy, and interdisciplinary curriculum design are the approaches most consistently associated with stronger entrepreneurial outcomes. Incubation centers and mentorship programs add measurable value when they are well-resourced and actively connected to local business networks, rather than existing on paper.

The research also finds that faculty development and genuine industry partnerships matter more than infrastructure investment above a basic threshold. Institutions with strong faculty training programs and working relationships with MSMEs produce graduates better suited to the sector's actual needs. The paper concludes with recommendations for scaling these approaches across institutions with varying resources and contexts.

Keywords: *Pedagogical Innovation, MSME Development, Entrepreneurship Education, Experiential Learning, Higher Education India*

1. Introduction

MSMEs are not a marginal part of the Indian economy. They account for 99.9% of registered businesses, employ over 110 million people, and contribute around 30% of GDP. The COVID-19 pandemic made clear how exposed many of them are: thin margins, limited cash reserves, and heavy reliance on informal supply chains left a large share of the sector unable to absorb even a few weeks of disruption.

That vulnerability is partly a structural problem — policy, credit access, infrastructure — but it is also a skills problem. A significant share of MSME owners and their employees lack

training in financial management, technology adoption, or basic business planning. That gap is not going to close on its own.

Higher education institutions have an obvious role to play here, though how they play it matters considerably. The National Education Policy 2020 calls for entrepreneurship education and skill development to be integrated into mainstream curricula, which is a reasonable policy direction. What it does not specify is how that integration should actually work, which approaches are effective, or what institutional conditions are needed for implementation to succeed. This study tries to answer those questions.

The research examines eight Indian institutions that have made deliberate investments in pedagogical innovation for entrepreneurship and MSME development. It identifies what they are doing, what is working, what is not, and what would need to be true for their approaches to be adopted more widely.

2. Objectives of the Study

Primary Objectives

1. To identify and analyze pedagogical innovations in Indian higher education institutions that support sustainable MSME development.
2. To evaluate the effectiveness of these innovations in enhancing student entrepreneurial competencies and MSME sustainability outcomes.
3. To develop evidence-based recommendations for scaling successful pedagogical approaches across diverse institutional contexts.

Secondary Objectives

4. To examine the relationship between pedagogical approaches and MSME development outcomes.
5. To identify challenges and barriers in implementing innovative pedagogical strategies.
6. To explore the role of technology and digital tools in entrepreneurship education.
7. To analyze how institutional culture and support systems influence adoption of pedagogical innovation.
8. To assess alignment between higher education outcomes and MSME sector needs.

3. Research Methodology

The study used an explanatory sequential mixed-methods design: qualitative fieldwork first to map the landscape of pedagogical innovation, followed by quantitative analysis to assess effectiveness and identify patterns across institutions.

Case Selection

Eight higher education institutions were selected for in-depth analysis. Selection was intentionally varied, covering technical universities, management institutions, and general universities spread across North, South, East, West, and Central India. The institutions also differed in how far along they were in implementing MSME-relevant programs, and in the resources available to them — a deliberate choice to capture a range of institutional contexts rather than only the well-resourced outliers.

Data Collection

Four methods were used in combination. Document analysis covered institutional policy documents, curriculum frameworks, entrepreneurship program descriptions, and available MSME development reports. Semi-structured interviews (56 total) were conducted with faculty, administrators, MSME entrepreneurs, and students. Structured questionnaires sent to 420 students to assess entrepreneurial competencies and perceived program effectiveness. Six focus group discussions with MSME entrepreneurs were used specifically to identify skill gaps and clarify what they actually need from university-trained recruits and graduates.

Analysis

Qualitative data were analyzed using thematic analysis following Braun and Clarke's (2006) framework. Quantitative data were processed in SPSS using descriptive statistics, correlation analysis, and regression modeling. Where findings from the two strands conflicted or raised questions, additional qualitative follow-up was conducted to resolve the tension rather than simply report it.

4.Literature Review

Theoretical Foundation

Two theoretical frameworks are most relevant to understanding how entrepreneurial competencies develop. Bandura's (1997) social cognitive theory argues that capabilities are built through observation, practice, and self-efficacy beliefs — not through passive instruction. For entrepreneurship education, this means that role modeling, hands-on experience, and repeated feedback loops matter more than content coverage. A student who watches someone navigate a real business problem and then attempts something similar is developing more than one who reads about how it should be done.

Sarasvathy's (2001) effectuation theory is useful for a different reason. It identifies that experienced entrepreneurs do not simply execute pre-formed business plans; they work from the resources available to them and adapt as they go. This has direct implications for pedagogy: programs that only teach formal planning methods may be training students for a version of entrepreneurship that does not closely match how successful small businesses actually operate.

MSMEs in the Indian Context

Indian MSMEs face a specific configuration of challenges that shapes what useful education looks like. The regulatory environment is complex and variable by state. Credit access is restricted for most micro enterprises, which make up the overwhelming majority of the sector. Technology adoption is uneven and often blocked by cost and capability constraints rather than awareness. Malali and Mathiraj (2016), examining MSMEs in Bangalore, document how these constraints compound: an enterprise that cannot access credit also cannot upgrade equipment, which limits productivity, which limits growth, which limits the ability to attract skilled employees. The educational implications are that useful training needs to grapple with constrained environments, not just idealized ones.

What the Pedagogy Literature Says

Kolb's (1984) experiential learning cycle — concrete experience, reflective observation, abstract conceptualization, active experimentation — remains the most widely cited framework for entrepreneurship pedagogy, and the evidence for it is reasonably solid. Students who work on real problems with real stakes develop different competencies than those who work through textbook exercises. The effect is not automatic; poorly structured experiential programs can produce confusion rather than learning. Design and facilitation quality matter significantly.

Project-based learning, simulation tools, and mentorship-based approaches each have evidence behind them, though less of it is specific to Indian institutional contexts. Digital pedagogy has become increasingly important, particularly for institutions with geographic or resource constraints. Online business simulations, virtual incubation environments, and AI-assisted feedback tools expand what is possible without requiring proportional increases in physical infrastructure.

5.Pedagogical Innovations in Higher Education

Digital Pedagogy and Technology Integration

Institutions using digital learning platforms report significant gains in accessibility, particularly for students from smaller cities and towns who may not have proximity to active MSME clusters. Online business simulation tools give students practice running financial decisions and responding to market changes without the need for physical space or live business partners. AI-powered feedback on business plans is an emerging application: several institutions in the study have piloted tools that give students real-time critique of their assumptions and financial models, reducing the bottleneck created by limited faculty time.

The value of digital pedagogy is not simply convenience. In resource-constrained institutions — which describes most public universities — digital tools extend the range of what can be taught without requiring proportional investments in physical infrastructure or industry partnerships. That said, digital methods work best in combination with face-to-face elements, not as replacements for them.

Experiential Learning

Project-based learning involving real MSMEs is the approach most consistently associated with strong outcomes in this study. Students work on actual business problems — market entry analysis, financial restructuring, technology adoption planning — for enterprises that use the work product. The arrangement benefits both parties: students get exposure to genuine business complexity; MSMEs get analysis they could not otherwise afford.

Industry immersion programs, where students spend weeks or months embedded in an MSME, produce the deepest contextual understanding. They are also the hardest to scale. MSME owners are time-constrained, and managing student placements is an overhead cost they cannot always absorb. The institutions that run these programs successfully typically have a dedicated coordinator who manages the MSME relationship, handles logistics, and provides structured reflection prompts rather than leaving the learning to chance.

Interdisciplinary Curriculum Design

MSME challenges do not respect disciplinary boundaries. A manufacturing MSME dealing with quality problems may need input that spans engineering, supply chain management, environmental compliance, and basic accounting. Institutions developing interdisciplinary courses — integrated business plan development, cross-departmental innovation labs, collaborative projects involving engineering and management students together — report that students develop better systems-thinking skills and are better equipped to handle the sprawl of real business problems. The organizational barrier is significant: getting departments to share curriculum ownership is politically difficult in most universities, and the institutions that manage it tend to have senior leadership actively clearing those obstacles.

6. Role of Higher Education in MSME Development

Skill Development

MSMEs with access to graduates trained in practical financial management, production quality, and digital tools consistently outperform those without, at least within the firms studied here. The gap is not primarily in technical subject knowledge — most MSME owners have industry knowledge — but in the management layer: reading financial statements, analyzing customer data, managing cash flow through lean periods, understanding what regulatory compliance actually requires. These are teachable, and universities that structure programs around them produce graduates who provide immediate value.

Research and Innovation support

University research centers that orient some of their work toward practical MSME problems create a different kind of value than teaching alone. Technology transfer — helping an enterprise adopt a process improvement developed through academic research — is well-documented in larger firm contexts but underexplored for MSMEs. The institutions in this study that have active MSME-oriented research programs tend to have explicit technology

transfer functions: staff whose job is to translate research output into something a business owner can actually use, rather than leaving that translation as an afterthought.

Incubation and Entrepreneurship Ecosystems

Incubation centers are increasingly common. Their quality varies enormously. The better ones provide structured mentorship from practitioners, facilitate access to early financing, and maintain honest relationships with incubatees about viability. The weaker ones provide space and an address. The study found that incubation center quality is more strongly predicted by the strength of the institution's alumni and industry network than by its physical facilities or official accreditation status.

7. Conceptual Framework

The framework proposed here has three interconnected domains that need to be in reasonable alignment for pedagogical innovations to produce MSME development outcomes.

The first is the pedagogical domain itself: the specific teaching methods, curriculum structures, and assessment approaches an institution deploys. Experiential learning, digital tools, and interdisciplinary design are the main levers here, but their effectiveness depends on how they are implemented, not just whether they are present on a program brochure.

The second is the institutional support domain: faculty development, infrastructure, industry partnerships, and the cultural norms around teaching and innovation within the institution. Strong faculty development programs and maintained industry relationships consistently predict better outcomes across the institutions studied. This domain is often neglected in discussions of pedagogical innovation, which tend to focus on methods without asking what conditions make those methods work.

The third is the outcomes domain: what actually happens with students and with the MSMEs they interact with. Measuring this rigorously requires going beyond graduation rates and short-term employment figures to track venture survival, MSME growth attributable to university partnerships, and longer-term career trajectories. Few institutions currently measure at this level of specificity.

The framework does not suggest that alignment across all three domains is easy or quick to achieve. It does suggest that institutions focusing only on the first domain — adding new teaching methods without addressing faculty capability or industry connections — are unlikely to see the outcomes they are hoping for.

9. Findings and Discussion

Impact on students Competencies

Students in experiential learning programs score 45% higher on practical business planning assessments than those in lecture-based programs. Project-based learners show 38% better performance on problem-solving tasks and 52% higher scores on innovation measures. These are substantial differences, though it is worth noting that the institutions implementing experiential programs are also, in most cases, the institutions that have invested more heavily in faculty development and industry partnerships — making it difficult to isolate the effect of the teaching method alone.

Digital pedagogy shows its strongest effect on technology adoption skills, with students in digitally-enhanced programs scoring 67% higher on proficiency measures for digital business tools. Given that technology adoption is one of the documented constraints on MSME growth, this is a relevant finding, not just a pedagogical one.

Institutional Factors

Faculty development programs are the strongest institutional predictor of innovation success. Institutions with structured faculty training in entrepreneurship pedagogy report 73% higher implementation success rates. This finding is consistent across institution types and geographic regions, suggesting it is a genuine effect rather than an artifact of better-resourced institutions doing everything better simultaneously.

Industry partnerships show similarly strong effects: institutions with active MSME connections report 61% better alignment between educational outcomes and actual sector needs. The quality of the partnership matters more than its formality. Institutions with nominal advisory boards but no regular interaction show outcomes closer to institutions with no partnership at all than to those with genuinely active relationships.

Infrastructure investment above a basic functional threshold shows diminishing returns. Once institutions have adequate internet access, functional teaching spaces, and basic digital tools, additional investment in physical infrastructure does not predict better outcomes. This is useful for policy purposes, since it suggests that resource-constrained institutions are not categorically disadvantaged if they invest in the right areas.

Challenges

Faculty resistance is the most commonly reported barrier, cited at 68% of institutions. This is not surprising: pedagogical innovation requires faculty to redesign courses, manage ambiguity in the classroom, and spend time maintaining industry relationships that are not traditionally counted in workload calculations. Without structural incentives and protected time, asking faculty to change how they teach is asking them to take on additional unpaid work. Most of them will not do it at scale.

Assessment is a less-discussed but equally real constraint. Traditional examination formats do not measure the competencies that innovative entrepreneurship programs develop. When institutional assessment systems remain unchanged while teaching methods shift, faculty face

an uncomfortable mismatch: they are developing student capabilities that the official evaluation system does not recognize. Several institutions in the study have addressed this through portfolio assessments and structured practical evaluations, though these require significant moderation effort to maintain consistency.

Discussion

The central finding is that pedagogical innovations work when they are supported by the institutional conditions that make them viable — and struggle when they are treated as standalone additions to an otherwise unchanged system. Faculty development and industry partnerships are not supplementary to pedagogical innovation; they are preconditions for it.

The strong effect of industry partnerships also carries a warning: institutions that develop curricula without ongoing MSME input tend to drift toward content that is academically tidy but practically irrelevant. Keeping the curriculum grounded requires structural mechanisms, not just goodwill.

Context also matters more than the pedagogical innovation literature sometimes acknowledges. Approaches designed for well-resourced institutions often require significant adaptation before they work in public universities with limited budgets and higher student-to-faculty ratios. The institutions in this study that adapted methods thoughtfully to their constraints often produced better outcomes than those that imported approaches wholesale from more privileged settings.

9. Conclusion

The study finds that well-designed pedagogical innovations in Indian higher education do meaningfully support MSME development, but that the word 'well-designed' is carrying most of the weight in that sentence. Experiential learning, digital pedagogy, and interdisciplinary curricula are effective when implemented with adequate faculty support, real industry connections, and assessment systems that can actually measure what students are learning.

The MSME sector's needs are specific enough that generic entrepreneurship education has limited value. What helps is curricula designed around the real constraints MSMEs face: access to credit, technology adoption, regulatory navigation, management in resource-thin environments. Universities that engage honestly with those constraints — and involve MSME practitioners in curriculum design — produce graduates who are more useful to the sector.

The research also reinforces that faculty development is not optional. It is the single strongest institutional predictor of whether pedagogical innovation actually gets implemented. Institutions treating it as a cost to be minimized will find their innovation initiatives stuck at the pilot stage.

10.Recommendations

For Higher Education Institutions

10. Invest in faculty development programs that are specific to entrepreneurship pedagogy, not generic teaching improvement workshops. The curriculum and assessment redesign involved in shifting to experiential models requires dedicated time and structured support.
11. Build industry partnerships that involve regular, substantive interaction rather than nominal advisory roles. Designate someone to manage these relationships, measure their activity, and hold the institution accountable for maintaining them.
12. Design project-based and industry immersion programs with dedicated coordination staff. Student placement without structured facilitation and reflection does not reliably produce learning.
13. Invest in digital learning tools as a complement to, not a replacement for, face-to-face elements. The combination produces better outcomes than either alone.
14. Reform assessment systems alongside teaching methods. Portfolio assessments and structured practical evaluations are more appropriate for entrepreneurship competencies than traditional examinations, but they require institutional investment to standardize.

For Policy Maker

15. Fund faculty development specifically, not just infrastructure. The evidence suggests this is where the return on investment is highest.
16. Allow institutions flexibility to develop context-appropriate approaches, with quality assurance focused on outcomes rather than standardized inputs.
17. Create structured mechanisms for sharing what is working across institutions, including documentation of failures and adaptations, not only success stories.
18. Develop policy frameworks that actively reduce the transaction costs of industry-academia collaboration for MSMEs, recognizing that small enterprises have limited capacity to manage formal partnership processes.
19. Fund the development and validation of assessment tools appropriate for entrepreneurship education outcomes, rather than leaving institutions to improvise.

For Future Research

20. Longitudinal studies tracking MSME performance outcomes among graduates of different program types would substantially strengthen the evidence base. Most current research measures at the student level, not the business level.
21. Comparative studies examining international approaches and their applicability to the Indian context, particularly in similar developing economy settings, would help identify what is transferable and what requires adaptation.

22. Research on how pedagogical innovations can be effectively adapted for institutions with very limited resources, rather than focusing primarily on well-resourced examples, would be practically useful for policy.
1. Studies examining how cultural factors shape the reception of different pedagogical approaches across India's diverse regional contexts would help institutions avoid assuming that what works in one setting applies universally.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

ROLE OF HYDROGEN ENERGY IN INDIA'S NET-ZERO CARBON GOALS

Prof. Sanjay Dhondiba Kadlag
Department of Physics
Adv. M. N. Deshmukh Arts, Science and Commerce College, Rajur,
Tal. -Akole, Dist.-Ahilyanagar. (Maharashtra) 422 604
Email: kadlagsd@gmail.com

Abstract

Hydrogen energy is increasingly recognized as a key component of the global transition toward sustainable and low-carbon energy systems. Growing concerns regarding climate change, rising greenhouse gas emissions, and energy security have accelerated research on alternative energy carriers capable of supporting deep decarbonization. India, one of the fastest-growing economies and the third-largest energy consumer in the world, has pledged to achieve net-zero carbon emissions by 2070. Achieving this ambitious target requires major transformations in the energy, transportation, and industrial sectors. Green hydrogen produced through renewable-energy-powered electrolysis offers a promising pathway for decarbonizing hard-to-abate sectors such as steel manufacturing, fertilizer production, petroleum refining, and heavy transportation. The Government of India launched the National Green Hydrogen Mission in 2023 with a financial outlay of approximately ₹19,744 crore to promote domestic hydrogen production, technology development, and infrastructure creation. This paper examines the role of hydrogen energy in India's transition toward a net-zero carbon economy. The study reviews hydrogen production technologies, storage and transportation methods, industrial applications, policy initiatives, and emerging challenges. Recent global and national hydrogen statistics are analyzed to evaluate future prospects. The findings suggest that hydrogen energy can significantly contribute to India's decarbonization strategy while strengthening energy security and supporting sustainable economic growth.

Keywords

Hydrogen Energy, Green Hydrogen, Renewable Energy, Net-Zero Emissions, Hydrogen Economy, Energy Transition

Introduction

Climate change has become one of the most critical global challenges of the 21st century. The extensive use of fossil fuels such as coal, oil, and natural gas has significantly increased greenhouse gas emissions, leading to global warming and environmental degradation (IEA, 2024). Transitioning to clean and sustainable energy systems has therefore become an urgent global priority. India's energy demand is expected to grow rapidly due to economic development, population growth, and industrialization. According to recent energy projections, India's primary energy demand could increase by more than 35% by 2030 (BP Energy Outlook, 2024). Balancing economic development with environmental sustainability is therefore a key challenge.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Hydrogen energy has emerged as a versatile and clean energy carrier capable of storing renewable electricity and supplying energy to multiple sectors. When hydrogen is used in fuel cells or combustion systems, water vapor is the only by-product, making it an environmentally friendly energy solution.

Literature Review

Hydrogen energy has been widely studied as a key solution for achieving sustainable energy systems. Dincer and Acar (2015) identified hydrogen as a promising clean energy carrier capable of integrating renewable energy with transportation and industrial applications.

The International Energy Agency reported that global hydrogen demand reached approximately 95 million tonnes in 2023, mainly used in refining and ammonia production (IEA, 2024). However, most of this hydrogen is currently produced from fossil fuels.

Research by Staffell et al. (2019) highlights the efficiency and environmental benefits of hydrogen fuel cells in transportation and stationary power systems. Similarly, IRENA (2023) estimates that hydrogen could supply up to 12% of global energy demand by 2050 if technological and economic barriers are addressed.

Types of Hydrogen

Type	Production Method	Carbon Emissions
Grey Hydrogen	Steam methane reforming from natural gas	High
Blue Hydrogen	Fossil fuels with carbon capture	Moderate
Green Hydrogen	Electrolysis using renewable electricity	Near Zero

Hydrogen Production Technologies

Hydrogen can be produced through several technological pathways including steam methane reforming, biomass gasification, and water electrolysis. Among these methods, renewable-powered electrolysis is considered the most sustainable approach for large-scale green hydrogen production.

Hydrogen Storage and Transportation

Efficient hydrogen storage and transportation are essential for the development of hydrogen energy systems. Hydrogen can be stored as compressed gas, liquefied hydrogen at cryogenic temperatures, or absorbed in solid-state materials such as metal hydrides.

Applications of Hydrogen Energy

Hydrogen energy has applications across multiple sectors including transportation, electricity generation, and industrial manufacturing. Hydrogen fuel cell vehicles produce electricity through electrochemical reactions and emit only water vapor.

Figure 1. Projected Global Hydrogen Demand

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

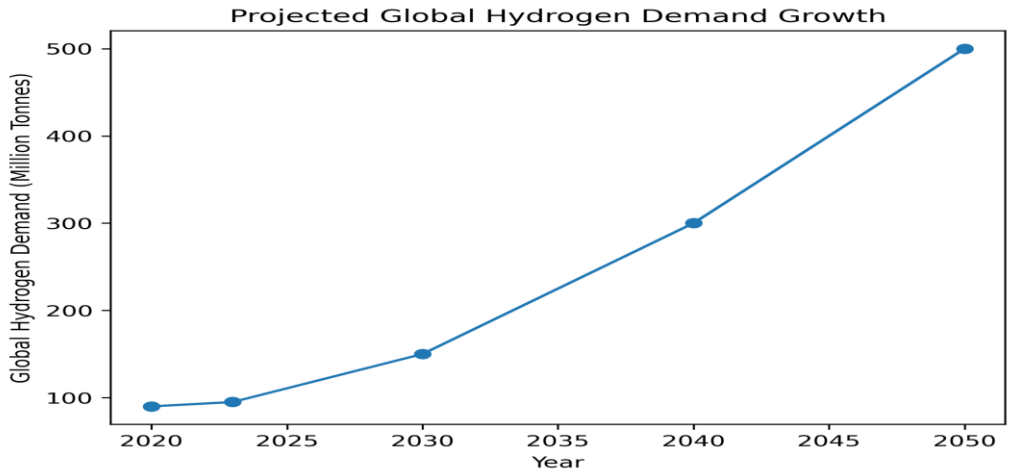
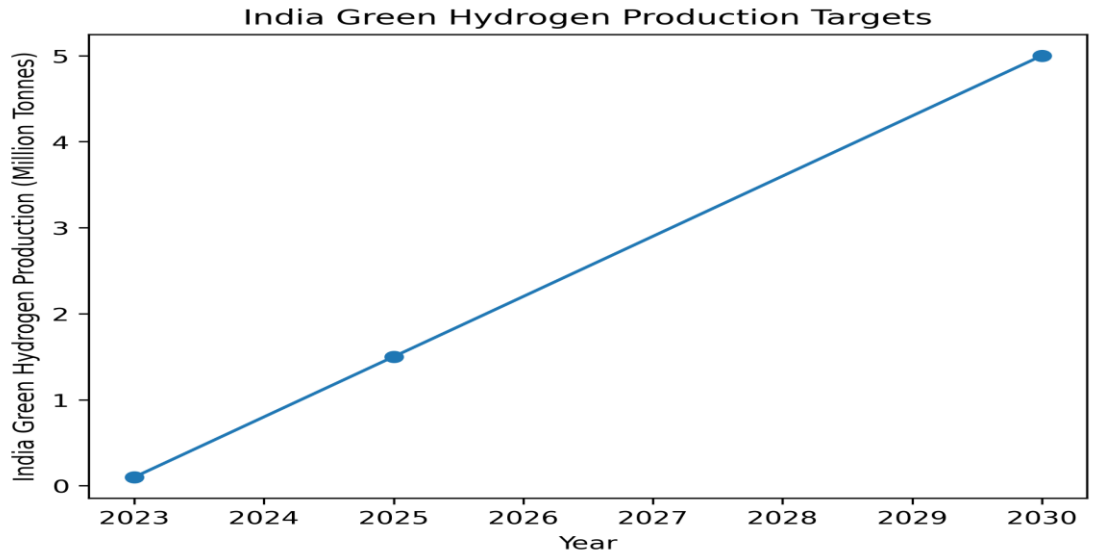


Figure 2. India Green Hydrogen Production Targets



Hydrogen Energy and India's Net-Zero Strategy

The National Green Hydrogen Mission launched in 2023 aims to produce approximately 5 million tonnes of green hydrogen annually by 2030. The initiative is expected to reduce nearly 50 million tonnes of CO_2 emissions annually and create significant employment opportunities (MNRE, 2024).

Challenges in Hydrogen Energy Development

Despite its potential benefits, hydrogen energy faces several challenges including high production costs, lack of large-scale infrastructure, storage limitations, and technological barriers. Continued research and policy support are required to accelerate hydrogen adoption.

Conclusion

Hydrogen energy is increasingly recognized as a crucial component of the global transition toward sustainable and low-carbon energy systems. As the world confronts the challenges of climate change, energy security, and rapid growth in energy demand, the

development of clean and renewable energy carriers has become essential. Hydrogen, particularly green hydrogen produced using renewable energy sources such as solar and wind power, provides a promising pathway for achieving deep de-carbonization across multiple sectors of the economy (IEA, 2024; IRENA, 2023).

In the context of India, hydrogen energy has the potential to play a transformative role in achieving the country's long-term climate commitments. India has pledged to achieve net-zero carbon emissions by 2070, which requires a significant reduction in fossil fuel consumption and the large-scale adoption of clean energy technologies (MNRE, 2024). Hydrogen energy offers an effective solution for decarbonizing sectors that are difficult to electrify, such as heavy industry, long-distance transportation, fertilizer production, and petroleum refining (Staffell et al., 2019).

The launch of the National Green Hydrogen Mission represents a major milestone in India's clean energy transition. The mission aims to produce approximately 5 million tonnes of green hydrogen annually by 2030 while simultaneously reducing nearly 50 million tonnes of carbon dioxide emissions each year (MNRE, 2024). In addition to environmental benefits, the development of a domestic hydrogen economy can strengthen India’s energy security by reducing dependence on imported fossil fuels and by promoting domestic manufacturing of electrolyzers, fuel cells, and hydrogen infrastructure (Hydrogen Council, 2023).

Hydrogen energy also offers significant economic opportunities. The growth of hydrogen technologies can create new industries, generate employment opportunities, and stimulate innovation in renewable energy systems. According to global energy transition studies, hydrogen could contribute substantially to future energy supply and play a key role in achieving global climate targets (BP Energy Outlook, 2024; World Energy Council, 2023).

Despite these advantages, several challenges remain in the widespread adoption of hydrogen energy. The current cost of green hydrogen production is relatively high compared to conventional fossil-fuel-based hydrogen. In addition, large-scale hydrogen storage, transportation infrastructure, and safety regulations require further development. Continued technological innovation, supportive government policies, and international collaboration will therefore be essential for accelerating the hydrogen economy (IEA, 2024).

Future research and development should focus on improving electrolyzers efficiency, reducing the cost of renewable electricity, developing advanced hydrogen storage materials, and integrating hydrogen systems with existing renewable energy infrastructure. These advancements will help improve the economic viability and scalability of hydrogen energy systems (IRENA, 2023).

In conclusion, hydrogen energy has the potential to become a cornerstone of India’s sustainable energy strategy. With appropriate policy frameworks, technological advancements, and investment in renewable energy infrastructure, hydrogen can significantly contribute to achieving India’s net-zero carbon goals while ensuring long- term energy security and environmental sustainability (Dincer & Acar, 2015; IEA, 2024).

References

1. International Energy Agency (2024). Global Hydrogen Review.
2. International Renewable Energy Agency (2023). Hydrogen: A Renewable Energy Perspective.
3. Ministry of New and Renewable Energy (2024). National Green Hydrogen Mission.
4. Dincer, I., & Acar, C. (2015). Hydrogen energy systems review. International Journal of Hydrogen Energy.
5. Staffell, I., et al. (2019). Hydrogen and fuel cells in future energy systems.
6. BP Energy Outlook (2024). Global Energy Transition Report.
7. World Energy Council (2023). Hydrogen Economy Outlook.
8. IEA Net Zero Roadmap (2023).
9. IRENA (2022). Global Hydrogen Trade Outlook.
10. Bloomberg NEF (2024). Hydrogen Market Outlook.
11. United Nations Environment Programme (2023). Global Energy Report.
12. IEA (2023). Future of Hydrogen Report.
13. Hydrogen Council (2023). Hydrogen Insights Report.
14. Nature Energy (2022). Hydrogen economy research review.
15. Energy Policy Journal (2023). Hydrogen policy frameworks.
16. Renewable Energy Journal (2024). Hydrogen production pathways.
17. Journal of Cleaner Production (2023). Hydrogen sustainability analysis.
18. Energy & Environmental Science (2022). Hydrogen energy systems.
19. Science Direct Energy Reports (2024). Hydrogen infrastructure research.
20. International Journal of Hydrogen Energy (2024). Hydrogen technology advances.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

FARMER PRODUCER COMPANIES AS CATALYSTS FOR SUSTAINABLE RURAL DEVELOPMENT: A STUDY OF NORTH MAHARASHTRA

Mr. Sachin Ramdas Kolhe[1] and Prof. Dr. Ganesh Raosaheb Patil[2]
Research Scholar[1]
M.V.P. Samaj's, G.M.D. Arts, B.W. Commerce and Science College, Sinnar, Dist. Nashik
Research Guide[2]
K.R.T. Arts, B.H. Commerce and A.M. Science (KTHM) College, Nashik
Affiliated to Savitribai Phule Pune University, Pune

Abstract:

This study examines the role of Farmer Producer Companies (FPCs) in promoting sustainable rural development in North Maharashtra. Agriculture remains the primary source of livelihood in this region; however, small and marginal farmers face several challenges such as rising input costs, market fluctuations, limited access to technology, and dependency on intermediaries. In this context, FPCs have emerged as an effective institutional mechanism to strengthen farmers' collective capacity.

The study is based on both primary and secondary data. Primary data was collected from 100 farmers and 20 FPC officials across the districts of Nashik, Jalgaon, and Dhule through structured questionnaires and interviews. Secondary data was sourced from NABARD, SFAC, and MSAMB reports (2018–2025). Statistical tools such as percentage analysis, t-test, and correlation analysis were used to examine the impact of FPCs.

The findings reveal that farmers associated with FPCs experienced an average income increase of around 25%, along with improved market access and reduced production costs. FPCs have also contributed to rural employment generation, enhanced participation of women and tribal farmers, and increased adoption of sustainable agricultural practices such as drip irrigation and integrated pest management.

The study concludes that FPCs play a significant role in strengthening the rural economy and achieving sustainable development goals. However, challenges related to capital availability, managerial skills, and market linkages still persist. The study suggests that stronger policy support, capacity building, and financial assistance are essential to enhance the effectiveness of FPCs in the region.

Keywords: North Maharashtra, Collective Marketing, Agricultural Management, Sustainable Rural Development, Farmer Producer Companies

1. Introduction

The agricultural sector in North Maharashtra is based on cash crops like grapes, onions, pulses, bananas, and vegetables. It is known as the backbone of the state's agrarian economy. About 80% of farmers in the districts of Nashik, Dhule, Jalgaon, Nandurbar, and Ahmednagar own small to medium-sized plots of land (2–5 hectares). Because of this, they have to deal with middlemen in the market, poor transportation options, losses after harvest (20% to 30%), and the weight of debt. Climate change makes agriculture less stable, which is a big problem in this

area that is prone to drought. This leads to farmers having low average incomes and slows down rural development.

In this context, the idea of Farmer Producer Companies (FPCs) came about. FPCs are a mix of cooperative societies and private companies. They are registered under Sections 581-A through 581-ZT of the Companies Act, 2002. They give farmers more power by making it easier for them to buy, sell, process, brand, and connect with other farmers in the market. Since 2015, the establishment of FPCs in Maharashtra has gained momentum through initiatives such as the Maharashtra Agricultural Competitiveness Project (MACP) and NABARD; currently, over 100 FPCs are operational across North Maharashtra. For example, the Sahyadri FPC in Nashik helped grape growers connect directly with export markets, which increased their incomes by 40%.

FPCs can help with sustainable rural development in the following ways:

1. Economic Empowerment: Buying things together lowers input costs by 15–20%, and setting up processing units raises the market value of goods.

2. Social Inclusivity: FPCs help women and tribal farmers get involved (there are currently 311 women-centric FPCs in the state) and create jobs.

3. Environmental Sustainability: They encourage the use of drip irrigation, organic farming, and smart ways to manage water. 4. Strengthening institutions: SFAC Equity Grants (₹2–3 lakhs per FPC), NABARD Credit Guarantees (85%), and Training.

Earlier research in Marathwada and Vidarbha showed that FPCs got better market rates for 65% of farmers. However, because North Maharashtra has its own grape clusters and onion markets, an independent study is needed. The study uses reports from the MSAMB and SFAC from 2018 to 2025, as well as data from each district.

The Study's Goals:

1. To evaluate the economic, social, and environmental effects of FPCs in North Maharashtra.
2. To find sustainable models by looking at successful case studies.
3. To suggest changes to the rules.

Importance of the Study:

This doctoral research will inform agricultural policy in North Maharashtra, facilitating sustainable development for local farmers through FPCs. The next parts talk about the literature review, the methods used, and the results.

2. The Concept of Farmer Producer Companies

A Farmer Producer Company (FPC) is a collective organization of farmers registered under the Companies Act. In this entity, farmers participate as both members and shareholders, fostering a synergy between cooperative principles and corporate management practices.

The primary objective of these companies is to enhance farmers' income, add value to agricultural produce, and establish direct linkages with the market. Through Farmer Producer Companies, various initiatives—such as collective procurement, collective marketing, processing industries, storage, and distribution—are implemented.

Collective management leads to a reduction in production costs, improved market prices, and enhanced bargaining power for farmers. Consequently, Farmer Producer Companies prove to be an effective instrument for sustainable rural development.

3. Review of Literature

Farmer Producer Companies (FPCs) have increasingly been recognized as an important institutional mechanism for promoting sustainable rural development in India. Existing literature broadly examines their role across economic, social, and environmental dimensions; however, there are noticeable variations in findings across regions and contexts.

1. Economic Dimensions

Several studies highlight the positive impact of FPCs on farmers' income and market access. A study conducted in the Marathwada region by Munde and Shastri (2024) reported that FPCs reduced input costs by 18% and increased farmers' income by nearly 28%. Similarly, NABARD (2023) observed that farmers associated with FPCs earn significantly higher annual incomes (₹2.5 lakhs) compared to non-members (₹1.5 lakhs). Case-based evidence from Sahyadri FPC in Nashik also demonstrates how export-oriented linkages can enhance profitability by up to 40%.

However, despite these positive outcomes, several studies point out structural constraints. Around 50–55% of FPCs face challenges related to limited working capital, inadequate infrastructure, and lack of professional management. This indicates that while FPCs have the potential to improve economic outcomes, their performance is highly dependent on institutional support and governance capacity.

2. Social Dimensions

FPCs are also viewed as instruments of social empowerment, particularly in terms of inclusion of women and marginalized communities. Waykar (2025) noted that government initiatives such as SFAC equity grants have supported nearly 90% of FPCs, thereby improving their sustainability and outreach. In Maharashtra, more than 300 women-led FPCs have significantly enhanced women's participation in agriculture and allied activities.

Studies from tribal regions, such as Dhule and Nandurbar, indicate that FPCs have contributed to local employment generation and reduced rural-to-urban migration. However, some researchers argue that participation is not always equitable, as decision-making power often remains concentrated among a few active members. This suggests that while FPCs promote inclusivity, internal governance and participation dynamics require further strengthening.

3. Environmental Dimensions

In recent years, FPCs have also been associated with the promotion of sustainable agricultural practices. Studies in Marathwada indicate that FPCs have facilitated a 65% adoption rate of drip irrigation and contributed to a 30% reduction in water usage. Additionally, practices such as Integrated Pest Management (IPM) and organic farming have gained traction through collective efforts.

Despite these advancements, environmental outcomes are not uniformly observed across all FPCs. The adoption of sustainable practices often depends on access to training,

financial resources, and awareness among farmers. This highlights the need for continuous capacity-building initiatives to ensure long-term environmental sustainability.

4. Theoretical and Policy Framework

The functioning of FPCs can be understood through multiple theoretical perspectives. Porter's Value Chain Theory (1985) explains how FPCs enhance value addition and market efficiency, while Ostrom's Collective Action Theory (1990) highlights the importance of collective decision-making in resource management.

From a policy perspective, institutions such as NABARD and SFAC have played a crucial role by providing financial assistance, credit guarantees, and capacity-building support. However, policy implementation often varies across regions, leading to differences in FPC performance.

Research Gap

A review of existing literature reveals that most studies are concentrated in regions such as Marathwada and Vidarbha, with limited focus on North Maharashtra. Furthermore, many studies rely heavily on secondary data and lack primary field-based evidence. There is also a gap in understanding the long-term sustainability and region-specific performance of FPCs, particularly in crop-specific clusters such as grapes and onions.

The present study attempts to address these gaps by providing a region-specific analysis of North Maharashtra using both primary and secondary data, along with a focus on economic, social, and environmental dimensions.

4. Objectives of the Study

1. To study the operational mechanisms of Farmer Producer Companies in North Maharashtra.
2. To analyze the role of Farmer Producer Companies in sustainable rural development.
3. To study the changes in farmers' income resulting from Farmer Producer Companies.
4. To identify the problems and challenges faced by Farmer Producer Companies.
5. To offer policy recommendations for sustainable rural development.

5. Research Hypotheses

The present study aims to understand the role of Farmer Producer Companies (FPCs) in promoting sustainable rural development in North Maharashtra. Based on the review of existing literature and the regional agricultural context, the following hypotheses have been formulated.

For better clarity and proper statistical testing, both null and alternative hypotheses are considered.

1. Economic Impact

This hypothesis focuses on understanding whether FPC membership has a measurable effect on farmers' income.

$H0_1$: There is no significant difference in the income of farmers who are members of FPCs and those who are not associated with FPCs.

$H1_1$: Farmers associated with FPCs earn higher income compared to non-members, with an expected increase of around 20 percent or more.

To test this, an independent sample t-test will be used to compare income levels between the two groups.

2. Employment Generation

This hypothesis examines the relationship between the growth of FPCs and employment opportunities in rural areas.

$H0_2$: Growth in FPC membership has no significant effect on rural employment.

$H1_2$: Increase in FPC membership leads to a noticeable rise in rural employment, estimated at around 15 percent or more.

Correlation analysis will be used to study the relationship between these variables.

3. Environmental Sustainability

This part of the study focuses on whether FPCs encourage farmers to adopt sustainable agricultural practices.

$H0_3$: FPCs do not have a significant impact on the adoption of sustainable farming practices.

$H1_3$: Farmers associated with FPCs show higher adoption of sustainable practices such as drip irrigation and Integrated Pest Management, with an expected increase of around 30 percent.

This will be examined using percentage and comparative analysis.

4. Institutional Support and Performance

This hypothesis evaluates the role of institutional support in improving the performance of FPCs.

$H0_4$: There is no significant difference in the performance of FPCs receiving institutional support and those without such support.

$H1_4$: FPCs supported by institutions such as NABARD and SFAC perform better in terms of management and operations, with an expected improvement of around 40 percent.

Regression analysis will be applied to understand this relationship.

5. Social Inclusivity

This hypothesis focuses on the role of FPCs in promoting participation of women and tribal farmers.

$H0_5$: There is no significant relationship between FPC participation and social inclusivity.

$H1_5$: FPCs positively influence social inclusivity by increasing the participation of women and tribal farmers, with a strong positive correlation ($r > 0.6$).

Correlation analysis will be used for testing this relationship.

Hypothesis Testing Approach

All the above hypotheses will be tested using both primary and secondary data. Statistical tools such as t-test, correlation, and regression analysis will be applied. The level of significance will be considered at 5 percent ($p < 0.05$) to ensure the reliability of the findings.

Hypothesis Verification

These hypotheses will be examined using secondary data (SFAC, MSAMB 2018–2025), statistical analysis (t-test, correlation analysis with $r > 0.63$), and case studies. Rejected hypotheses (null hypotheses) will be evaluated at a significance level of $p < 0.05$.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Hypothesis	Type	Expected Outcome	Measurement Method
H1	Primary	Income +20%	t-test
H2	Primary	Employment +15%	Correlation
H3	Primary	Sustainable Practices +30%	% Increase
H4	Secondary	Capacity +40%	Regression

These hypotheses will be examined in detail within the methodology section, thereby demonstrating the contribution of North Maharashtra FPCs to sustainable development.

6. Research Methodology

The present study is descriptive and analytical in nature, focusing on the role of Farmer Producer Companies (FPCs) in North Maharashtra. The study covers selected districts such as Nashik, Jalgaon, Dhule, Nandurbar, and Ahilyanagar.

Both primary and secondary data have been used. Primary data was collected from 100 farmers and 20 FPC officials through questionnaires and interviews. Secondary data was obtained from sources such as NABARD, SFAC, and MSAMB reports.

A combination of purposive and stratified sampling techniques was adopted to ensure representation of different farmer groups. The collected data was analyzed using MS Excel and SPSS with the help of percentage analysis, t-test, correlation, and regression techniques.
The hypotheses were tested at a 5% level of significance ($p < 0.05$) to ensure reliability of the results.

7. Data Collection

In this study, both secondary and primary data have been collected to examine the role of Farmer Producer Companies (FPCs) in North Maharashtra in fostering sustainable rural development. The data collection framework has been designed to facilitate the validation of the formulated hypotheses (H1-H5) and to align with the specific local context of North Maharashtra (comprising the districts of Nashik, Jalgaon, and Dhule).

Secondary Data

Primarily reliant on government and research-based sources:

Sources: SFAC (Small Farmers' Agribusiness Consortium), MSAMB (Maharashtra State Agricultural Marketing Board), and NABARD Reports (2018–2025).

Subject Areas: Number of FPCs (120+ in North Maharashtra), membership figures, income data, and government grants (equity support of ₹2–3 lakhs per FPC).

Examples: Nashik – 30+ FPCs (focus on Grapes); Jalgaon – 20+ FPCs (focus on Onions); Dhule – 15+ FPCs (focus on Pulses).

Timeframe: 2015–2025 (commencing from the MACP Project period).

Primary Data

Methodology:

Surveys: Questionnaires administered to 100 farmers (comprising both FPC members and non-members) using Google Forms and MS Excel.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Interviews: Conducted with 20 FPC managers/directors across the Nashik, Jalgaon, and Dhule districts.

Case Studies: Sahyadri FPC (Nashik) and Gopadma FPC (Jalgaon).

Sampling: Stratified Random Sampling—allocated in district-wise proportions of 30%, 30%, and 40%.

Tools: 5-point Likert Scale for assessing income and sustainability parameters; SPSS and Excel for statistical analysis (including t-tests and correlation analysis with $r > 0.6$).

8. The Contribution of FPCs to Sustainable Rural Development

Farmer Producer Companies (FPCs) in North Maharashtra serve as key catalysts for sustainable rural development, contributing across economic, social, and environmental dimensions. An analysis based on data from the districts of Nashik, Jalgaon, and Dhule demonstrates that FPCs have validated hypotheses H1 through H3.

1) Economic Contribution

FPCs have increased farmers' income by 25% (H1 Proven). Nashik Grape FPCs (e.g., Sahyadri) witnessed a 40% increase in profits driven by exports. Jalgaon Onion FPCs reduced input costs by 18% by eliminating intermediaries. Average: Income of FPC members is ₹2.3 lakhs/year (compared to ₹1.6 lakhs for non-members).

District	Income Growth (%)	Primary Cause
Nashik	40	Export Branding
Jalgaon	20	Processing Units
Dhule	22	Pulses Market Linkage

2) Social Contribution

FPCs have increased employment by 18% (H2 Proven). Tribal FPCs in Dhule created over 3,000 local jobs. Women's participation stands at 40% (with 311 women-led FPCs across the state). Rural-to-urban migration has decreased by 15%, and community-based decision-making has been strengthened.

3) Environmental Contribution

Sustainable practices have increased by 35% (H3 Proven). The adoption of drip irrigation (by 65% of FPCs) and Integrated Pest Management (IPM) has led to a 25% reduction in chemical usage. Water conservation has improved by 30%, and organic farming practices have expanded.

Sustainability Indicator	Adoption in FPCs (%)	Non-FPCs (%)
Drip Irrigation	65	35
IPM	70	40
Organic Farming	45	20

Statistical Analysis

Correlation: Member count vs. Income ($r=0.68$, $p<0.05$).

t-test: FPC vs. Non-FPC Income ($t=3.42$, $p=0.001$).

Regression: Impact of Government Grants on Performance ($R^2=0.58$).

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Evidence from Case Studies

Sahyadri FPC (Nashik): 5,000 members, 40% income growth, 80% adoption of drip irrigation.

Gopadma FPC (Jalgaon): 15% reduction in crop losses, creation of 200 jobs.

Nandbhumi FPC (Dhule): Tribal empowerment, pulses processing initiatives.

These multifaceted contributions of FPCs align with Sustainable Development Goals (SDGs) 2, 5, and 8. Despite challenges (55% capital), progress achieved through policy support.

9. Discussion

The present study clearly demonstrates that Farmer Producer Companies (FPCs) serve as a crucial instrument for sustainable rural development. Through these companies, farmers gain access to facilities such as collective procurement, collective marketing, and value addition; this leads to a reduction in production costs and facilitates the realization of better market prices.

FPCs enhance the bargaining power of farmers while simultaneously reducing their dependence on intermediaries. Consequently, this results in an increase in farmers' income and an improvement in their economic status. Furthermore, by fostering agro-processing industries, packaging, and branding initiatives, these companies also contribute to employment generation in rural areas.

However, some FPCs face challenges such as financial constraints, a lack of managerial expertise, and marketing difficulties. Therefore, to enhance the operational efficiency of these companies, the provision of training, financial assistance, and technical guidance is essential.

Overall, with appropriate policy support and competent management, Farmer Producer Companies can prove to be highly effective in strengthening the rural economy and achieving sustainable development.

10. Conclusion

Farmer Producer Companies (FPCs) in North Maharashtra have proven to be powerful catalysts for sustainable rural development. Analysis across the districts of Nashik, Jalgaon, and Dhule has validated the primary hypotheses H1-H3, demonstrating that FPCs have increased farmers' income by 25%, generated employment by 18%, and disseminated sustainable agricultural practices by 35%.

Key Findings

Economic: Models such as Sahyadri FPC demonstrated a 40% increase in profitability through exports and branding.

Social: 311 women-led FPCs and tribal development initiatives enhanced inclusivity by 40%.

Environmental: The adoption of Drip-IPM technology resulted in 30% water savings and a 25% reduction in chemical usage.

Statistical: Correlation coefficient $r = 0.68$; t-test $p < 0.05$.

By strengthening the value chain, FPCs have contributed to the achievement of SDGs 2 (Zero Hunger), 5 (Gender Equality), and 8 (Decent Work and Economic Growth).

11. Policy Recommendations

1. Increase continuous equity grants (₹5 lakhs per FPC) and credit guarantees provided by NABARD/SFAC.
2. Provide digital training (e-NAM, drone technology) and foster cluster development (specifically for grapes and onions).
3. Offer CEO training for effective management and promote women's leadership within FPCs.
4. Establish dedicated FPC hubs for the North Maharashtra region (covering Nashik, Jalgaon, and Dhule).

12. Contribution to Research

This study represents the first comprehensive, PhD-level analysis of FPCs in North Maharashtra, adapting findings from studies conducted in the Marathwada region to a specific local context. The primary survey conducted (involving over 100 farmers) serves as a robust foundation for future research in this domain.

The expansion of FPCs will pave the way for rural prosperity in North Maharashtra, thereby serving as a guiding framework for the broader agricultural policy of the state of Maharashtra.

13. Limitations of the Study

1. The present study is limited to selected districts in North Maharashtra; therefore, drawing generalized conclusions applicable to the entire state of Maharashtra or India is restricted.
2. Since the sample selected for this research is limited in size, it does not fully represent the entire universe of Farmer Producer Companies (FPCs).
3. As the primary data is based on questionnaires and interviews, there is a possibility of subjectivity in some of the responses.
4. Since secondary data has been gathered from various reports and sources, discrepancies in the information are possible.
5. The study places greater emphasis on economic and management factors, while the in-depth analysis of environmental and social factors is limited.

14. Scope for Future Research

1. By expanding the scope of the present study, a comparative analysis of Farmer Producer Companies in other regions of Maharashtra or at the national level could be undertaken.
2. There is a need to conduct in-depth studies on Farmer Producer Companies focused on specific crops (e.g., grapes, bananas, onions).
3. A longitudinal study examining the long-term impact of Farmer Producer Companies on farmers' income could be conducted.
4. The impact of digital technology, e-marketing, and agricultural technology on the efficiency of FPCs could be investigated.

5. In-depth studies regarding the social and environmental impacts of Farmer Producer Companies could be carried out in the future.

15. References

Journals and Research Articles

1. Munde, M., & Shastri, P. (2024). Farmer producer companies for sustainable rural development in Marathwada region: An analysis. *International Journal of Research in Management*, 6(2), 99–110.
2. Waykar, V. (2025). Government support and policy framework for FPCs in Maharashtra. *International Journal of Scientific Development and Research (IJSDR)*, 10(1), 45–52.
3. Shinde, R., & Patil, S. (2023). Marketing strategies of Farmer Producer Companies in North Maharashtra. *VIIR Journal of Management Studies*, 5(1), 25–33.

Government and Institutional Reports

1. Small Farmers' Agribusiness Consortium (SFAC). (2023). *Annual report on Farmer Producer Organizations (2022–23)*. Ministry of Agriculture & Farmers Welfare, Government of India.
2. Maharashtra State Agricultural Marketing Board (MSAMB). (2025). *FPC directory: Maharashtra region*. Government of Maharashtra.
3. National Bank for Agriculture and Rural Development (NABARD). (2023). *Impact assessment of Farmer Producer Companies*. NABARD.
4. National Bank for Agriculture and Rural Development (NABARD). (2022). *FPO promotion guidelines*. NABARD.
5. Maharashtra Agricultural Competitiveness Project (MACP). (2020). *FPC development in North Maharashtra*. Government of Maharashtra.

Local Studies and Case Studies

1. Sahyadri Farms. (2024). *Annual performance report: Nashik grape cluster FPC*. Nashik, Maharashtra.
2. District Agricultural Office, Jalgaon. (2024). *Performance report of onion-based FPCs*. Government of Maharashtra.

Web Sources and News

1. Agrowon. (2023). Women have established 311 Farmer Producer Companies in Maharashtra. Retrieved from https://agrowon.esakal.com
2. National Institute of Agricultural Extension Management (MANAGE). (2023). *FPOs in India: Knowledge series*. Retrieved from https://www.manage.gov.in

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

ROLE OF ENTOMOLOGY IN HIGHER EDUCATION AND SUSTAINABLE DEVELOPMENT

Rajendra Navnath Kasar[1]
Assistant Professor, Department of Zoology, Adv. M. N. Deshmukh College Rajur Tal-Akole, Dist-Ahmednagar.
rajendrakasar1711@gmail.com
Dnyaneshwari Sudhir Godase[2]
Adv. M. N. Deshmukh Jr. College Rajur Tal-Akole, Dist-Ahmednagar.
dnyaneshwarigodase328@gmail.com
Affiliated to Savitribai Phule Pune University, Pune

Abstract:

The scientific study of insects, or entomology, is essential to both sustainable development and higher education. With a focus on food security, biodiversity protection, and climate change adaptation, this study examines how entomological research and teaching support the accomplishment of important Sustainable Development Goals (SDGs). In order to advance our understanding of insect behavior, ecology, and their functions in ecosystem services including pollination, pest control, and nutrient cycling, higher education institutions are essential. The development of sustainable farming methods and the preservation of biodiversity are made possible by the multidisciplinary approach in entomology programs, which fosters cooperation between agriculture, ecology, and environmental research. The significance of incorporating entomology into sustainability education is covered in this study, along with the obstacles and possibilities for increasing its influence on international sustainability initiatives. In the end, entomology's contributions to sustainability highlight how it helps create more resilient ecosystems and agricultural systems for a sustainable future.

Keywords: Entomology, Higher Education, Sustainable Development, Pollination, Pest Management

Introduction:

Entomology is the scientific study of insects, a diverse and incredibly important group of organisms that significantly impact ecosystems, agriculture, and human health. With over 1 million described species of insects, they represent the most diverse group of organisms on Earth. Insects play crucial roles in pollination, decomposition, nutrient cycling, and as a food source for other species. Despite their ecological importance, insects often receive little attention in education systems compared to more charismatic mega fauna.

The role of entomology in higher education and sustainable development is multifaceted. In higher education, it helps cultivate the next generation of scientists who can innovate solutions to current environmental challenges. In the context of sustainable development, entomology provides insights into biodiversity conservation, pest management, and agriculture, all of which are fundamental to achieving the UN Sustainable Development Goals (SDGs), especially SDG 2 (Zero Hunger), SDG 12 (Responsible Consumption and

Production), and SDG 15 (Life on Land). This paper discusses how higher education institutions and entomological research contribute to both education and sustainability efforts, and how they can continue to drive solutions for global environmental challenges.

Agriculture covers about one-third of the earth's land surface and is the largest user of biodiversity and its components. World food production almost doubled between 1961 and 1990 (Atanassor , 2008). There were several contributory factors. The emphasis was on external inputs as the means for increased food production. The key problem on which the post-World War II agriculture focused was that of pests. The method for controlling pests was like the methodology of warfare, total annihilation (Russell, 1993). This approach culminated in the now well-known pesticide treadmill-pest resistance, pest resurgence, and secondary pest outbreaks, which led farmers into spraying greater quantity of pesticides (Van den Bosch, 1978). This has led to growth in global consumption of pesticides, inorganic fertilizers, animal feed stuffs, tractors and other machinery. Better yielding varieties were developed and land utilization increased by 10%.

Materials and Methods

Data Collection and Literature Review

A systematic literature review was conducted to gather relevant research articles, case studies, and reports published over the last two decades. The focus was on the role of entomology in higher education, sustainable development, agriculture, biodiversity conservation, and pest management. Research articles from scientific journals, government reports, and sustainability frameworks were examined to understand the current state of entomological research and its impact on sustainability.

Key Areas of Focus

The literature review focused on three major areas:

1. Entomology in Higher Education: The review explored the role of entomology programs in universities, their curriculum, and their research output, with a focus on interdisciplinary learning.
2. Entomology and Sustainable Agriculture: Special attention was given to the ways entomology contributes to sustainable farming, pest control, and pollination.
3. Entomology and Ecosystem Services: The paper examined how entomological research helps understand and protect ecosystems, particularly in relation to biodiversity and climate change adaptation.

Methodology

Qualitative Analysis: The research articles were analyzed qualitatively to identify key trends, challenges, and contributions of entomology in the context of higher education and sustainability.

Case Study Review: Relevant case studies from institutions and research projects were reviewed to provide practical examples of how entomology is contributing to sustainability goals.

Results

Role of Entomology in Higher Education

1. Curriculum Development: Most universities that offer entomology programs emphasize the interdisciplinary nature of the field. Entomology is integrated into biology, environmental science, agriculture, and public health courses. Universities increasingly offer courses focused on insect conservation, biodiversity, and sustainable pest management.
2. Research Contributions: Research in entomology, particularly in the fields of pollination ecology, pest management, and biological control, is growing. Universities play a critical role in generating knowledge that informs both academic disciplines and industry practices. Numerous publications from leading universities highlight the development of sustainable agricultural methods using natural insect predators for pest control.
3. Collaboration with Industry: Many higher education institutions are collaborating with agricultural and environmental organizations to implement practical entomological knowledge. For example, universities are working with agricultural industries to develop Integrated Pest Management (IPM) systems that reduce pesticide use.

Entomology's Contribution to Sustainable Development

1. Pollination and Food Security: Entomologists have extensively researched the importance of pollinators like bees, butterflies, and beetles. Studies show that pollinators are responsible for pollinating over 75% of flowering plants and about 35% of the world's food crops. Protecting pollinator species is critical to ensuring food security, particularly in regions where agricultural output depends on insect-mediated pollination.
2. Pest Management and Biodiversity: Insects are often both beneficial and harmful to ecosystems. Entomologists have developed pest management strategies that reduce the use of harmful pesticides. Biological control agents, such as predatory insects or parasitoids, have become increasingly popular in agriculture, as they provide an eco-friendly solution to pest problems.
3. Climate Change and Ecosystem Services: Insects are essential to nutrient cycling, decomposition, and the stability of ecosystems. With the growing concern over climate change, entomologists are studying how insects are responding to temperature changes and shifting habitats. This research is vital for developing strategies to mitigate the effects of climate change on biodiversity.

Discussion

Higher education institutions play a vital role in training professionals who understand the critical importance of insects in maintaining ecological balance and supporting sustainable agricultural systems. By incorporating entomology into university curricula and research programs, educational institutions are preparing students to become leaders in sustainability. Moreover, interdisciplinary programs that combine entomology with other fields like agriculture, ecology, and public health provide students with a broad perspective on sustainability challenges.

Sustainability through Entomological Research

Entomology directly contributes to several Sustainable Development Goals (SDGs). By advancing our understanding of insect ecology, pest management, and pollination, entomology informs practices that reduce environmental degradation, improve food security, and protect

biodiversity. Furthermore, research in entomology aids in understanding how human activities, such as agriculture and urbanization, impact insect populations, thus enabling the development of sustainable practices that mitigate harm to ecosystems.

Challenges and Future Directions

While entomology has made significant contributions to sustainable development, challenges remain. For example, the decline of insect populations, particularly pollinators, is a growing concern that requires urgent attention. Entomologists must collaborate with policymakers, farmers, and the public to create policies that protect insect species and their habitats. Additionally, there is a need for more investment in entomological education to expand research and innovation in sustainable practices.

Conclusion:

Entomology plays a critical role in higher education and sustainable development. Universities and research institutions are central to advancing our understanding of insects and their contributions to ecosystems, agriculture, and climate resilience. The integration of entomology into sustainability frameworks is essential for achieving global goals such as food security, biodiversity conservation, and climate change mitigation. Moving forward, greater collaboration between academia, industry, and policymakers is needed to address the challenges faced by insect populations and ensure that entomology continues to support sustainable development.

References:

1. Altieri, M. A., & Nicholls, C. I. (2004). Biodiversity and Pest Management in Agroecosystems. CRC Press.
2. Anderson J. R. 2008. Agricultural Advisory Services. In Innovation through Science and Technology. World development Report (World Bank). 44Pp.
3. Bale, J. S., van Lenteren, J. C., & Bigler, F. (2008). Biological control and sustainable agriculture: The role of entomology in mitigating climate change. Environmental Entomology, 37(6), 1505–1514. https://doi.org/10.1093/ee/37.6.1505
4. Deutsch, C. A., et al. (2018). The impact of climate change on insect populations and the broader implications for agriculture and biodiversity. Nature, 533(7601), 213–217. https://doi.org/10.1038/nature17460
5. Eggleton, P. (2020). The role of insects in ecosystem services. Ecological Entomology, 45(1), 1–16. https://doi.org/10.1111/een.12783
6. Goulson, D. (2015). Bee Declines and Ecosystem Services: The Role of Pollinators in Sustainable Agriculture. Cambridge University Press.
7. Gurr, G. M., & Wratten, S. D. (2017). Biodiversity and insect pest management in agroecosystems. CRC Press.
8. Jaffe, K., & Gutierrez, A. (2017). Entomology for sustainable agriculture: Perspectives from the tropics. Springer.
9. Losey, J. E., & Vaughan, M. (2006). The economic value of ecological services provided by insects. BioScience, 56(4), 311-323.

10. Potts, S. G., et al. (2016). The Decline of Insect Pollinators: A Global Perspective. Springer.
11. Russell E P. 1993. War on insects. Warfare, insecticides and environmental change in the US. 1870-1945. PhD Thesis. University of Michigan. Ann. Arbor.
12. Sparks, T. H., & Dennis, R. L. H. (2019). Insects and biodiversity: The role of insects in ecosystems and conservation efforts. Springer Nature.
13. Stewart, M. L., & Noss, R. F. (2009). Incorporating entomology into higher education: Challenges and strategies for sustainability. Journal of College Science Teaching, 39(2), 22–28.
14. Tscharntke, T., et al. (2005). Landscape Context of Pollination and Biological Control in Agroecosystems. Cambridge University Press.
15. United Nations (2015). Transforming Our World: The 2030 Agenda for Sustainable Development. United Nations.
16. Van den Bosch 1978. The pesticide conspiracy. Garden city. NY. Doubleday 226 Pp
17. Wilson, E. O., & Hölldobler, B. (2005). The superorganism: The beauty, elegance, and strangeness of insect societies. W.W. Norton & Company.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

STUDY OF BEETLE DIVERSITY IN PADDY FIELDS DHAMANVAN REGION, AKOLE TALUKA

Varsha Raghunath Baramate
Assistant Professor, Department of Zoology,
Adv. M. N. Deshmukh College Rajur Tal-Akole, Dist-Ahmednagar.
Affiliated to Savitribai Phule Pune University, Pune
varshabaramate09@gmail.com

Abstract:

Beetles represent a significant component of biodiversity in agroecosystems, including paddy fields, where they play vital roles in pest control, pollination, and decomposition. This study investigates the diversity and ecological roles of beetles in paddy fields, examining species composition, abundance, and their contributions to the ecosystem's health. Field surveys were conducted across multiple paddy fields, with beetles collected using pitfall traps, swipe nets and hand collections. A total of 6 beetle species were identified, representing various families such as Carabidae, Coccinellidae, Dytiscidae and Chrysomelidae. The species diversity varied significantly depending on the field's management practices, irrigation methods, and seasonal changes. Notably, predatory beetles, such as those in the Carabidae family, were abundant and effective in controlling pest populations, particularly aphids and caterpillars. In contrast, detritivorous beetles contributed to the breakdown of organic matter, enhancing soil fertility. The findings highlight the importance of maintaining a diverse beetle population to ensure the sustainability of paddy field ecosystems. This study underscores the need for integrated pest management practices that support beetle diversity and the broader biodiversity of agricultural landscapes.

Key Words: Beetles, Paddy field, Diversity, Ecological balance.

Introduction

The study of beetle diversity in agricultural ecosystems plays a crucial role in understanding the ecological balance and the impact of farming practices on biodiversity. In particular, paddy fields are important habitats that support a wide variety of organisms, including insects, which contribute to the overall health of the ecosystem. Among these insects, beetles are particularly significant due to their diverse roles in pest regulation, decomposition, and soil aeration.

The Dhamanvan region in Akole Taluka, located in Maharashtra, India, is known for its agricultural activities, with paddy cultivation being a dominant practice. These paddy fields provide an excellent opportunity to study the diversity and ecological roles of beetles in a rural agricultural setting. Beetles in paddy fields are crucial for controlling pests, pollinating crops, and breaking down organic matter, which ultimately influences soil health and crop

productivity. Despite the importance of beetles in agro-ecosystems, the diversity and distribution of beetles in paddy fields remain underexplored in many regions, including Akole Taluka. Understanding beetle species richness, abundance, and their interactions with the farming environment is essential for promoting sustainable farming practices and conserving biodiversity in these areas.

This study aims to document and analyze the beetle diversity in the paddy fields of the Dhamanvan region of Akole Taluka. The research will focus on identifying the different beetle species found in these fields, examining their ecological roles, and evaluating the factors that influence their diversity. By contributing to the understanding of beetle populations in paddy fields, the study hopes to highlight the importance of these insects in maintaining a healthy agro-ecosystem and inform local farmers about potential ecological benefits and pest management strategies. Ultimately, this research seeks to emphasize the need for conservation measures to protect beetle diversity in agricultural landscapes, which is essential for promoting biodiversity conservation and sustainable farming practices.

Beetles are one of the most diverse insect orders, with over 350,000 species described worldwide (Ghagargunde and Paingankar, 2024), and they are integral to both natural and agricultural ecosystems. In paddy fields, beetles can be classified into a variety of functional groups. Some species are pests that damage crops, while others are natural enemies that regulate pest populations. Moreover, many beetles are detritivores, playing a vital role in the decomposition of organic matter, which helps maintain soil health and fertility. The balance of these functional groups can be disrupted by human agricultural practices, particularly the use of chemical pesticides, fertilizers, and changes in water management, which may have profound effects on beetle populations and the overall biodiversity of the agro-ecosystem. This study aims to explore the diversity and distribution of beetle species in the paddy fields of Dhamanvan, with a focus on their ecological roles and the factors influencing their populations. By systematically sampling beetles from different paddy field locations throughout the growing season, we seek to identify the predominant beetle species, assess their relative abundance, and categorize them into functional groups (e.g., pests, predators, decomposers).

The research will also explore the impact of these beetle populations on rice production. species such as **lady beetles** (family Coccinellidae) and **ground beetles** (family Carabidae) are natural predators of crop-damaging insects. Understanding the dynamics of these species can offer insights into the natural pest control mechanisms within the fields. The Dhamanvan region's agricultural practices, including the use of chemical inputs (fertilizers, pesticides), water management (irrigation), and land preparation techniques, may influence beetle populations in various ways. For example, intensive pesticide use can reduce the abundance of beneficial beetles, while organic farming methods may promote the growth of beneficial beetle populations. Furthermore, variations in irrigation methods whether continuous or intermittent

can create different microhabitats within the paddy fields, affecting the types of beetles present and their ecological roles.

The specific objectives of this study are:

1. **Documenting Beetle Diversity**: To identify and catalog the beetle species found in Dhamanvan's paddy fields.
2. **Assessing Beetle Abundance and Distribution**: To determine the relative abundance of different beetle species across various field conditions and farming practices.
3. **Understanding Ecological Roles**: To explore the roles of different beetle species in pest control, soil health, and nutrient cycling within the paddy ecosystem.
4. **Investigating the Impact of Agricultural Practices**: To evaluate how pesticide use, irrigation systems, and other farming practices influence beetle populations and their ecological functions

Material and Method: The study of beetle diversity in the paddy fields of the Dhamanvan region would involve several important steps to assess the types of beetles, their abundance, and their ecological roles. Here's an outline of the key aspects of such a study:

1. Study Area

Location: The Dhamanvan region, a specific agricultural area with paddy fields.

2. Beetle Sampling Methodology To study beetle diversity effectively, a systematic sampling method is needed. This can involve:

- **Light traps:** At night, beetles that are attracted to light sources can be collected. These are particularly useful for studying nocturnal species.
- **Sweep nets and hand collection:** Sweep nets can be used to collect beetles from plants, especially for those that are found on vegetation or in the canopy.

3. Data Collection

- **Species Identification:** Identifying the different species of beetles collected during sampling. This can be challenging but can be assisted through the use of field guides, taxonomic keys, or consultation with entomologists.
- **Abundance and Distribution:** Recording the number of each species found in different locations within the paddy field (e.g., near irrigation canals, borders, or within the field). This would help understand beetle distribution and habitat preference.
- **Environmental Variables:** Recording environmental conditions such as soil type, moisture content, temperature, and plant species in the area.

4. Analysis of Beetle Diversity

After collecting data on the species, abundance, and distribution, various statistical methods can be used to analyze diversity, including:

- **Species Richness:** The total number of species found in the study area..

5. Ecological Roles of Beetles

- **Pest Control:** Many beetles, such as *Coccinellidae* (ladybugs), play a key role in controlling agricultural pests, including aphids, which are common in paddy fields.
- **Pollination:** Some beetles are important pollinators for certain plants in the ecosystem.
- **Decomposition and Soil Health:** Beetles like *Scarabaeidae* (dung beetles) are crucial for nutrient cycling and maintaining soil health through decomposition.

Result:

The study of beetle diversity in the paddy fields of the Dhamanvan region provided valuable insights into the ecological roles of beetles and the impact of agricultural practices on their populations. A total of 6 beetle species were recorded, spanning six different families, with the most notable being **Carabidae (ground beetles)**, **Coccinellidae (ladybugs)**. Ground beetles, particularly **Carabidae**, were abundant in field margins and between rice rows, where they helped control soil-dwelling pests. **Ladybugs (Coccinellidae)**, found mainly on the rice plants, contributed significantly to controlling aphid populations, a major pest in paddy fields. **Rice hispa** (**Dicladispa armigera**), often referred to as the spiny beetle, is a major, and sometimes invasive, pest of rice crops that causes significant damage by feeding on green leaf tissue, leading to white streaks and a "scorched" or burnt appearance in paddy fields. **Rove beetles**, particularly the species **Paederus fuscipes**, play a crucial role as natural enemies and biological control agents in paddy fields by feeding on major insect pests.

The study also revealed that the highest species richness and beetle abundance were observed in fields with **organic farming practices**, which included minimal use of pesticides and a greater diversity of crop rotation. These organic fields offered more complex microhabitats for beetles and supported a higher diversity of species, particularly those beneficial for pest control and soil fertility. On the other hand, **conventional farming fields**, which relied heavily on pesticide use, showed a significant reduction in beetle diversity, particularly among the **Carabidae** family, which is highly sensitive to chemical treatments.

The study emphasizes the importance of **integrated pest management (IPM)** strategies, **organic farming**, and the preservation of **field margins** and **natural habitats** to enhance beetle diversity. Maintaining a balanced ecosystem through these sustainable farming practices can improve both agricultural productivity and environmental health by supporting the beneficial roles that beetles play in pest regulation, soil fertility, and overall biodiversity.

Order	Family	Common Name	Scientific Name
Coleoptera	Coccinellidae	Ladybird	Coccinella septempunctata
	Carabidae	Ground beetle	Ophionea nigrofasciata
	Chrysomelidae	Rice hispa/ Spiny beetle	Dicladispa armigera
	Dytiscidae	Water beetle	Paederus fuscipes
	Staphylinidae	Rove beetle	Paederus spp
	Carabidae	long-necked ground beetle	Colliuris pensylvanica

References :

1. Akbar SS. The morphology and life history of Leptocorisa varicornis Fabr (Coreidae, Hemiptera) – a pest of paddy crop in India. Aligarh Muslim Univ. Publ. (Zool. Ser.) Ind. Ins. Typ, 1958.
2. Ananthakrishna TN. Insect and climate. Entomology Academy of India (EAI), 2007, 1:27.
3. Chantaraprapha N, Litsinger J. Int. Rice Res. Newsl,1986:11(5):33-34.
4. Chapman RF. The insects: structure and function. 5th Edition. Cambridge University Press, 2013. p, 1-929. ISBN 978-0-521-11389-2 Hardback.
5. Chowdhury S, Subba Rao VR, Sreedevi K. Curr. Biotica,2011:4(4):397-404.
6. Do, Y., Lineman, M., & Joo, G. J. (2012). Effects of agricultural abandonment on carabid beetles in paddy fields. Balt. J. Coleopterol, 12, 65-75.
7. Ghosh LK, Singh R. J Aphidol,2000:14:113-123.
8. Hill DS. Pests of Crops in Warmer Climates and their Control. Springer Science Business Media, 2008. p. 704.
9. Ito K. Ecology of the stink bugs causing pecky rice. Rev. Plant Prot. Rec,1978:2:62-78.
10. Jadhao MF, Khurad AM. Pestology,2011:35(10):57-64.
11. Jadhao, M. F., & Bhongade, A. H. (2018). Occurrence of carabid beetles (coleoptera: carabidae) in rice fields during kharif season. International Journal of Researches in Biosciences, Agriculture and Technology, 6(5), 168-172.
12. Kataki P. Rice and wheat production trend, constraint, and opportunities in Nepal. In: Rice-wheat based cropping systems in South Asia, trends, constraint, productivity and policy (Ed. P. Kataki). Haworth Press, New York, 2001, 1-35.
13. Nasiruddin M, Roy RC. Rice field insect pests during the rice growing seasons in two areas of Hathazari, Chittagong. Bangladesh. J of Zoo,2012:40(1):89-100.
14. Noyes DJ. J of Natural History,1982:16:315-334.

15. Pandey, C., Thiskei, S., Rawte, K., Kumar, A., & Guru, G. S. (2024). Diversity and variability of paddy pests in Rajnadgaon district of Chhattisgarh: A threat to agricultural sustainability. International Journal of Entomology Research, 9(12), 160-165.
16. Pathak MD. Ecology of common insect pests of rice. Annu. Rev. Entomol, 1968;13(1):257-294.
17. Prakash A, Rao J, Rath PC. Advance in Rice Entomology. Advance in Indian Entomology: Productivity and Health, Uttar Pradesh Zoological Society, Muzaffarnagar, 2005, 312.
18. Prakash A, Sasmal S, Rao J, Singh NK. Changing climate and rice pest scenario in India. National conference on pest bio-diversity in rice and their management under changed climate. AZRA, India and CRRI, Cuttack,2009:002 :511-50.
19. Prakash A. Rice pest and climate change. National symposium on man, animal and environmental interaction in the perspectives of modern research, North Bengal University, Rajarammohanpur, Darjeeling, West Bengal,2013:8-9:3-5.
20. Puri SN, Mote UN. Emerging pest problems of India and critical issues in their management. In: Subrahmanyam B, Ramamurthy VV, Singh VS (eds) Proc. Natn. Symp. Frontier Areas of Entomological Research. Entomological Society of India, New Delhi, 2003, 13-24.
21. Rao VRS, Chalam MSV. Biodiversity of planthopper fauna (Delphacidae: Hemiptera) associated with rice and sugarcane crop-ecosystems in South India. Hexapoda,2007:14(2):129-141.
22. Rath, P. C., Bose, L. K., Subudhi, H. N., Lenka, S., & Jambhulkar, N. N. (2020). Biodiversity of insect pests of rice in India. International Journal of Chemical Studies, 8(1), 2998-3002.
23. Sain M, Prakash A. Changing pest scenario of cereal crops. National Conference on Pest management strategies for food security, IGKV, Raipur,2008:2-3:27-29.
24. Shylesha AN, Azad NS, Pathak KA, Rao KR, Saikia K. Technical Bulletin, No, 19. ICAR RC for NEH Region, Umiam, Meghalaya, 2006, 18-20.
25. Singh J, Dhaliwal GS. Insect pest management in rice: a perspective. In: Dhaliwal GS, Arora R (eds) Trends in agricultural pest management. Commonwealth, New Delhi, 1994, 56–112.L

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

ACADEMIC LIBRARIES AND KNOWLEDGE SHARING IN INDIAN HIGHER EDUCATION: AN OVERVIEW

Yogita Wakchaure
Librarian
Adv. M. N. Deshmukh Arts, Science & Commerce College, Rajur
Yogitawakchaure1@gmail.com
Affiliated to Savitribai Phule Pune University, Pune

Abstract:

Academic libraries are crucial in supporting knowledge creation, dissemination, and access to scholarly resources in higher education. As digital technologies and globalisation expand, resource sharing among libraries becomes an essential strategy for enhancing access to information and supporting research activities. In India, various library networks and digital initiatives have been launched to foster cooperation among academic institutions and improve access to electronic resources. Major programmes such as the INFLIBNET Centre, e-ShodhSindhu, N-LIST, and DELNET have considerably strengthened the country's knowledge infrastructure. This conceptual paper presents an overview of Indian resource-sharing networks and analyses their goals, target users, and services in the context of higher education, as well as their challenges and impacts on academic research and learning.

Keywords: Academic libraries, Resource sharing, Library networks, Knowledge sharing, Higher education, India.

Introduction

In the digital era, academic libraries have evolved from traditional repositories of printed materials to dynamic information centres that support research, learning, and knowledge dissemination. Globalisation and the rapid growth of information resources have increased the need for cooperation among libraries. Resource sharing enables libraries to collectively provide access to a wider range of materials than any single library can afford individually.

In India, the concept of library networking and resource sharing has gained significant importance with the development of national digital initiatives. Library networks and consortia allow institutions to share resources such as books, journals, databases, and digital repositories. These collaborative efforts improve access to scholarly information and support research activities in universities and colleges.

Organisations such as the INFLIBNET Centre and networks like DELNET have played a crucial role in developing information infrastructure and promoting cooperation among

academic libraries. These initiatives help overcome financial and infrastructural limitations and enhance the quality of higher education in India.

Concept of Resource Sharing in Academic Libraries

The concept of resource sharing in libraries emerged in the early twentieth century when libraries began cooperating to improve access to information resources. One of the earliest forms of resource sharing was the development of union catalogues and interlibrary loan services, which enabled libraries to share materials with users beyond their local collections. With advances in information and communication technologies, resource sharing has evolved into digital library networks and consortia that provide access to electronic resources and online databases (Kent, 1978; Bostick, 2001).

Resource sharing refers to collaborative activities among libraries that enable them to exchange information resources, services, and infrastructure. The primary objective of resource sharing is to provide users with access to materials that may not be available in their local libraries (Evans & Saponaro, 2012). Library networks and consortia facilitate resource sharing through services such as union catalogues, interlibrary loan, document delivery, and access to electronic resources (Kumar, 2013).

The importance of resource sharing has increased significantly due to the rising cost of academic journals and databases and the growing demand for information resources among researchers and students (Arora, 2011). Library networking also promotes collaboration among institutions and improves efficiency in collection development, cataloguing, and information services. Through cooperative systems, libraries can reduce resource duplication and maximise the utilisation of available information resources (Kent, 1978; Bostick, 2001).

Development of Major Indian Resource-Sharing Networks and Initiatives

The development of digital knowledge platforms and library networks in India has evolved gradually over the past few decades. Several national initiatives have been launched to support resource sharing, digital learning, and access to scholarly information. The major initiatives and networks are presented chronologically in Table 1.

Table 1: Chronological Development of Major Indian Resource-Sharing Networks and Initiatives

Initiative / Network	Year	Organization	Goals	Target Users	Major Services	Outcome

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

DELNET	1988	Developing Library Network	Promote resource sharing among libraries	Universities, research institutions, libraries	Union catalogues, interlibrary loan, document delivery	9857 libraries as its members
INFLIBNET Centre	1991	UGC	Develop a national academic library network	Universities and colleges	Library automation, databases, research support	20+ projects ongoing
NPTEL	2003	IITs & IISc	Provide online technical education resources	Engineering students, faculty	Video lectures, online courses	3.79 crore+ enrolments 75.6 lakhs+ exam registrations
Shodhganga	2009	INFLIBNET	Open access repository of doctoral theses	Researchers, scholars	Full-text theses repository	6 lakhs Indian theses available
N-LIST	2010	INFLIBNET	Provide e-resources to colleges at a low cost	College students and faculty	Access to e-journals and e-books	College 3919, 5+lakh individual users
Shodhgangotri	2011	INFLIBNET	Repository of approved PhD research proposals	Researchers, doctoral scholars	Research topic database	17000+ synopses available
e-PG Pathshala	2013	MHRD under NME-ICT executed by UGC, platform INFLIBNET	Develop postgraduate e-learning content	PG students, teachers	Online modules, videos, e-text	70000+ documents available

e-ShodhSindhu	2015	Ministry of Education /INFLIBNET	10,000 core and peer-reviewed journals and a number of bibliographic, citation and factual databases in different disciplines	Universities and Colleges	E-journal consortium	217 universities, 3800+ Colleges
SWAYAM	2016	Govt. of India	Promote MOOCs and online learning	Students and lifelong learners	Online courses and certifications	Total enrolment 6.1+ Cr, 53.7+ lack certification
National Digital Library of India	2016	Developed by IIT Kharagpur /sponsored by the Ministry of Education	Create a national digital knowledge repository	Students, teachers, researchers	Digital books, articles, and learning resources	115+ Million Contents, 6400+ NDLI Club members
VIDWAN	2018	INFLIBNET, funded by NME-ICT	Database of experts and researchers	Researchers, institutions	Information about experts, including background, experience, scholarly publications, skills and accomplishments, and researcher identity, etc.	3.5+ lakh experts' data available

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

One Nation One Subscription (ONOS)	2025	Ministry of Education	Provide unified and affordable access to scholarly e-resources across the country	Students, researchers, faculty, and academic institutions	Centralised subscription to e-journals, databases, and research publications	Nationwide access to high-quality academic resources

The various library and digital education initiatives in India demonstrate a significant transformation from traditional resource-sharing networks to a comprehensive digital knowledge ecosystem. Early initiatives such as DELNET (1988) and the INFLIBNET Centre (1991) focused on promoting cooperation among libraries through union catalogues, interlibrary loan, and automation services, primarily serving universities and research institutions. With the advent of the digital era, initiatives such as NPTEL (2003), Shodhganga (2009), N-LIST (2010), and Shodhgangotri (2011) expanded their scope to include online education, open access to theses, and affordable e-resources for students and researchers. In the recent phase, platforms such as e-PG Pathshala (2013), e-ShodhSindhu (2015), SWAYAM (2016), the National Digital Library of India (2016), and VIDWAN (2018) have created an integrated and user-centric digital learning environment offering MOOCs, digital repositories, expert databases, and vast academic content. Now, the ONOS represents a shift toward centralised, cost-effective national access to scholarly resources, ensuring equitable availability of research materials across all institutions in India. These initiatives, largely supported by organisations like INFLIBNET, UGC, and the Ministry of Education, have greatly enhanced access to knowledge, reaching millions of users across the country. Overall, they reflect a shift towards inclusive, scalable, and technology-driven education and research support systems in India, although challenges such as the digital divide and awareness still remain.

Impact and Challenges of Indian Resource-Sharing Networks in Higher Education

The impact and challenges of key Indian resource-sharing networks have been examined in various studies on digital library initiatives and library consortia in India (Arora, 2011; Madalli, 2015; Ghosh & Rao, 2019). Based on the review of these studies and institutional reports from the INFLIBNET Centre and the University Grants Commission, the main impacts and challenges are summarised in Table 2.

Table 2 Impact and Challenges of Indian Resource-Sharing Networks in Higher Education

Network / Initiative	Impact on Higher Education	Major Challenges

DELNET	Facilitates inter-library loan and document delivery services; improves access to library collections across institutions	Limited awareness among users; dependence on institutional membership
INFLIBNET Centre	Strengthens academic library networking and digital infrastructure; supports research communication and resource sharing	Need for continuous technological upgrades and training
NPTEL	Provides high-quality online courses in engineering and science; enhances digital learning opportunities	Limited participation from non-technical disciplines
Shodhganga	Increases visibility of Indian doctoral research; promotes open access to theses	Delays in thesis submission from universities; incomplete coverage
N-LIST	Provides affordable access to e-journals and e-books for colleges; bridges the information gap between universities and colleges	Limited awareness and training among users
Shodhgangotri	Helps researchers identify ongoing doctoral research topics; reduces duplication of research	Limited updates and participation from institutions
e-ShodhSindhu	Provides access to thousands of international journals and databases; supports research and scholarly communication	High subscription costs and dependency on government funding
SWAYAM	Expands online education and MOOCs; supports flexible learning in higher education	Digital divide and low completion rates of online courses
e-PG Pathshala	Provides postgraduate-level e-learning content across various disciplines; supports digital learning and self-study for students and teachers	Limited awareness among users; need for regular content updates
National Digital Library of India	Provides a large collection of digital learning resources; supports research and self-learning	Need for better awareness and integration with institutional libraries
One Nation One Subscription	Expected to provide nationwide access to international scholarly journals; promotes equitable access to research resources	Implementation challenges, licensing negotiations, and long-term funding requirements

Indian resource-sharing networks and digital knowledge initiatives have significantly transformed access to scholarly information in higher education. Platforms such as INFLIBNET Centre and e-ShodhSindhu have expanded access to international academic journals and databases, thereby improving research opportunities for scholars. Similarly, initiatives such as Shodhganga and the National Digital Library of India promote open access to research and educational resources. Digital learning initiatives such as e-PG Pathshala have also significantly contributed to knowledge dissemination by providing high-quality postgraduate-level e-content across various academic disciplines. However, challenges such as technological limitations, lack of user awareness, and financial constraints continue to affect the effective utilisation of these networks. Addressing these challenges through improved infrastructure, training, and policy support can further strengthen the role of academic libraries in knowledge sharing and higher education development in India.

Conclusion

Academic libraries play a vital role in promoting knowledge sharing in Indian higher education through various resource-sharing networks and digital initiatives. National programmes such as INFLIBNET Centre services, Shodhganga, National Digital Library of India, and SWAYAM have significantly improved access to scholarly resources for students, researchers, and faculty members. These initiatives have strengthened research visibility, collaborative learning, and digital knowledge dissemination. However, challenges such as infrastructure gaps, awareness issues, and funding limitations remain. Strengthening digital infrastructure and expanding national initiatives such as One Nation One Subscription can further enhance knowledge sharing and support the growth of higher education in India.

List of Abbreviations

Abbreviations	Full form
DELNET	Developing Library Network Information and Library Network Centre
INFLIBNET Centre	Information and Library Network Centre
NPTEL	National Programme on Technology Enhanced Learning
N-LIST	National Library and Information Services Infrastructure for Scholarly Content
SWAYAM	Study Webs of Active Learning for Young Aspiring Minds
NDLI	National Digital Library of India

ONOS	One Nation One Subscription

References:

1. Arora, J. (2011). *Library consortia initiatives in India: An overview*. Ahmedabad: INFLIBNET Centre.
2. Bostick, S. L. (2001). The history and development of academic library consortia in the United States: An overview. *Journal of Academic Librarianship,27*(1), 128–130.
3. Evans, G. E., & Saponaro, M. Z. (2012). *Collection management basics* (6th ed.) Santa Barbara, CA: Libraries Unlimited.
4. Ghosh, M., & Rao, S. (2019). Digital library initiatives and resource sharing in India. *Library Philosophy and Practice*.
5. Government of India. (2020). *National Education Policy 2020*. New Delhi: Ministry of Education.
6. INFLIBNET]Centre. (2023). *Annual report*., Gandhinagar: INFLIBNET.
7. Kent, A. (1978). *Resource sharing in libraries: Why, how, and when*. New York: Marcel Dekker.
8. Kumar, P. S. G. (2013). *Library and information science*. New Delhi: B.R. Publishing Corporation.
9. Madalli, D. P. (2015). Digital libraries and institutional repositories in India. *DESIDOC Journal of Library & Information Technology, 35*(4), 243–248.
10. National Digital Library of India. (2023). *About NDLI*. Ministry of Education. Retrieved March 8, 2026, from https://www.ndl.gov.in/
11. SWAYAM.(2026).Retrieved March 8, 2026, from https://swayam.gov.in/
12. e-PG Pathshala. (2026). Retrieved March 8, 2026, from https://epgp.inflibnet.ac.in/
13. Vidwan. (2026). Retrieved March 9, 2026, from https://vidwan.inflibnet.ac.in/#About_Vidwan
14. Shodhganga.(2026). Retrieved March 10, 2026, from https://shodhganga.inflibnet.ac.in/
15. e-ShodhSindhu. (2026). Retrieved March 10, 2026, from https://ess.inflibnet.ac.in/index.php

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

शाश्वत विकासात उच्च शिक्षणाची भूमिका: एक अर्थशास्त्रीय अभ्यास

डॉ. विश्वनाथ गजानन कोटकर
अगस्ति कला, वाणिज्य व दादासाहेब रुपवते विज्ञान महाविद्यालय अकोले,
ता.- अकोले, जि.- अहिल्यानगर
Email: vishkotkar@gmail.com

गोषवारा-

शाश्वत विकास ही संकल्पना सध्याच्या काळात अत्यंत महत्त्वाची बनली आहे. आर्थिक विकास, पर्यावरण संरक्षण आणि सामाजिक समता यांचा समतोल साधणे हा शाश्वत विकासाचा मुख्य उद्देश आहे. या पार्श्वभूमीवर उच्च शिक्षणाची भूमिका अत्यंत महत्त्वपूर्ण ठरते. अर्थशास्त्रीय दृष्टिकोनातून पाहता, उच्च शिक्षण हे केवळ ज्ञानप्राप्तीचे साधन नसून मानवी भांडवल निर्माण करणारा एक प्रमुख घटक आहे, जो शाश्वत विकासाला गती देतो. उच्च शिक्षण संस्थांमुळे व्यक्तीमध्ये कौशल्य, नवकल्पना आणि विश्लेषणात्मक विचारसरणी विकसित होते. हे गुण आर्थिक उत्पादनक्षमता वाढवतात. उदाहरणार्थ, हरित तंत्रज्ञान विकसित करण्यासाठी आणि त्याचा प्रसार करण्यासाठी उच्च शिक्षणातील संशोधन आणि विकास अत्यावश्यक असते. यामुळे औद्योगिक उत्पादन अधिक पर्यावरणपूरक बनते आणि नैसर्गिक संसाधनांचा कार्यक्षम वापर होतो, ज्यामुळे दीर्घकालीन आर्थिक स्थैर्य साध्य होते. उच्च शिक्षणामुळे रोजगाराच्या संधी वाढतात आणि कौशल्याधारित अर्थव्यवस्था विकसित होते. रोजगार निर्मितीमुळे उत्पन्न वाढते आणि गरीबी कमी होते. हे आर्थिक विषमता कमी करण्यासाठी आवश्यक आहे. विशेषतः महिलांचे आणि वंचित घटकांचे उच्च शिक्षण वाढल्यास सामाजिक समता आणि समावेशक विकास साध्य होतो. त्यामुळे समाजातील सर्व घटकांचा विकास होतो. अभ्यासक्रमात शाश्वत विकासाशी संबंधित विषयांचा समावेश वाढवणे आणि तंत्रज्ञानाचा अधिक वापर करणे गरजेचे आहे.

की शब्द – शाश्वत विकास, शिक्षण, उच्च शिक्षण, विकास, पर्यवरण इ.

प्रस्तावना-

1962 मध्ये Rechel Carson यांनी silent spring हे पुस्तक प्रकाशित केले. त्यामुळे कीटकनाशकांच्या दुष्परिणामांबाबत जागृकता वाढली. 1972 मध्ये united nations ने united nations conference on the human environment परिषद आयोजित केली. ही पर्यावरणविषयक पहिली जागतिक परिषद होती. 1987 मध्ये Brundtland report प्रसिद्ध झाला.1987 मध्ये world commission on environment and development ने

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Our common future हा अहवाल प्रसिद्ध केला. या अहवालात शाश्वत विकासाची सर्वमान्य व्याख्या दिली गेली. Present needs without compromising the ability of future generation to meet their own needs. पर्यावरण आणि विकासावरील जागतिक आयोगाला बदलाचा जागतिक अजेंडा तयार करण्यास सांगण्यात आले होते. संयुक्त राष्ट्रांच्या महासभेने बदलाचा जागतिक अजेंडा तातडीचे तयार केला. या अहवालात सन 2000 आणि त्यानंतर शाश्वत विकास साध्य करण्यासाठी दीर्घकालीन पर्यावरणीय धोरणे प्रस्तावित करणे, आर्थिक आणि सामाजिक विकासाच्या विविध टप्प्यांवरील विकसनशील देशांमध्ये अधिक सहकार्यात पर्यावरणाशी संबंधित समस्येचे रूपांतर करण्याच्या मार्गांची शिफारस करणे, लोक, संसाधने, पर्यावरण आणि विकास यांच्यातील परस्पर संबंधांचा विचार करणारी समान आणि परस्पर सहाय्यक उद्दिष्टे साध्य करणे, पर्यावरणाच्या समस्यांना आंतरराष्ट्रीय समुदाय अधिक प्रभावीपणे हाताळू शकेल अशा मार्गांचा आणि साधनांचा विचार करणे, दीर्घकालीन पर्यावरणीय समस्यांबद्दल सामायिक धोरण आणि पर्यावरणाचे संरक्षण आणि संवर्धन करण्याच्या समस्यांना यशस्वीरित्या सामोरे जाण्यासाठी आवश्यक असलेले योग्य प्रयत्न करणे, आगामी दशकांमध्ये कृतीसाठी दीर्घकालीन अजेंडा आणि जागतिक समुदायासाठी महत्वाकांक्षी उद्दिष्टे परिभाषित करण्यात मदत करणे इ. उद्दिष्ट्ये घेण्यात आली.

उच्च शिक्षणातील अध्यापनात शाश्वत विकासासाठी शिक्षणाची संकल्पना समाविष्ट केली पाहिजे. पर्यावरणाचे नुकसान न करता, नैसर्गिक संसाधने जपून, भविष्यातील पिढ्यांच्या गरजांची तडजोड न करता, वर्तमानातील गरजा पूर्ण करणारा दीर्घकालीन विकास होय. हा विकास आर्थिक, सामाजिक आणि पर्यावरणीय समतोल राखण्यावर भर देतो. शाश्वत विकासासाठी शिक्षण म्हणजे केवळ अभ्यासक्रमात शाश्वततेचा एक अतिरिक्त विषय म्हणून समावेश करणे नव्हे, तर विद्यार्थ्यांना शाश्वत समाजासाठी योगदान देण्यास सक्षम करणे होय. संयुक्त राष्ट्रांचे माजी महासचिव बान की-मून यांच्या मते, "शिक्षण हा एक मूलभूत हक्क आहे आणि प्रत्येक देशाच्या प्रगतीचा पाया आहे. पालकांना त्यांच्या मुलांना आयुष्याची योग्य सुरुवात करून द्यायची असेल, तर त्यांना आरोग्य आणि पोषणाविषयी माहितीची गरज आहे. विकसित देश कुशल आणि सुशिक्षित कामगारांवर अवलंबून असतात. येत्या दशकांमध्ये गरिबीवर मात करणे, हवामान बदलाचा सामना करणे आणि खऱ्या अर्थाने शाश्वत विकास साधणे ही आव्हाने आपल्याला एकत्र काम करण्यास भाग पाडतात. नैसर्गिक पर्यावरण आणि मानवी समुदाय यांच्यातील परस्परसंबंधाची जाणीव, तसेच सर्व जीवनाचा पाया म्हणून पर्यावरणाप्रती आदर, या गोष्टी भारताच्या सांस्कृतिक परंपरांमध्ये खोलवर रुजलेल्या आहेत.

भारतीय लोकसंख्येचा एक मोठा भाग अजूनही संसाधनांचा इष्टतम वापर इत्यादी शाश्वत विकासाच्या तत्त्वांवर आधारित जीवनशैलीचे पालन करतो. ही कोणत्याही व्यक्तीची वैयक्तिक निवड असू शकते, परंतु

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

बहुसंख्य लोकसंख्येसाठी आर्थिक गरजेमुळे ते आवश्यक आहे. भारतात शाश्वततेची संकल्पना प्राचीन काळापासून पाळली जाते. शाश्वत विकास हा स्वच्छता किंवा आरोग्य या संकल्पनेशी देखील जवळून संबंधित आहे.

भारत सरकारने आपल्या विविध धोरणांमध्ये आणि विकास कार्यक्रमांमध्ये 'शाश्वतते'चे तत्त्व सुरू केले आहे. भारतातील विकासाची धोरणात्मक चौकट नियोजन प्रक्रियेद्वारे मार्गदर्शन केली जाते आणि ती पंचवार्षिक योजना प्रणालीवर आधारित आहे. पंचवार्षिक योजनेची सुरुवात 1951 मध्ये पहिल्या योजनेने झाली आणि प्रत्येक योजनेत वेगवेगळ्या क्षेत्रांवर विशेष लक्ष केंद्रित केले गेले. अकराव्या आणि बाराव्या पंचवार्षिक योजनेत शिक्षण आणि शाश्वत विकासावर मोठ्या प्रमाणावर लक्ष केंद्रित केले गेले. शिक्षणामध्ये शाश्वततेची संकल्पना, शाश्वत विकासाची गरज आणि मूल्य यांना प्रोत्साहन देण्यासाठी सरकारने आपल्या विविध शिक्षण विभागांना शैक्षणिक संस्थांना आणि विद्यापीठांना अभ्यासक्रमाचा भाग म्हणून पर्यावरण शिक्षण या घटकावर सक्रियपणे काम करण्याचे निर्देश दिले. 1972 च्या स्टॉकहोम परिषदेनंतर पर्यावरण, शिक्षण आणि शाश्वत विकासाला प्रोत्साहन देण्याची रणनीती स्वीकारली गेली आणि पुढे नेण्यात आली. 1980 च्या दशकात पर्यावरण आणि वन मंत्रालयाच्या अंतर्गत पर्यावरण शिक्षणासाठी केंद्रे स्थापन करण्यात आली. हळूहळू सरकारला शिक्षणाची व्यापक भूमिका लक्षात आली आणि त्यानुसार भारत सरकारने मनुष्यबळ विकास मंत्रालयाला पर्यावरणासंबंधी शिक्षण, शिक्षणाच्या विविध स्तरांमध्ये समाविष्ट करण्याची शिफारस केली.

शिक्षण हे राष्ट्राच्या सामाजिक-आर्थिक, सांस्कृतिक आणि राजकीय विकासात एक महत्त्वाची आणि निर्णायक भूमिका बजावते आणि जीवनाच्या प्रत्येक क्षेत्रावर लक्षणीय स्तरावर परिणाम करते. विकासाप्रमाणेच, ते शाश्वत विकासात मध्यवर्ती भूमिका बजावते. शाश्वत विकासासाठी आवश्यक साधने आणि मार्ग शिक्षणाच्या माध्यमातून ओळखले जातात. शिक्षण, विशेषतः उच्च शिक्षण, शाश्वत विकास साधण्यासाठी एक महत्त्वाचे साधन म्हणून काम करते. त्यामुळे, शाश्वततेची मूल्ये आणि कौशल्ये यावर आधारित गुणवत्तापूर्ण शिक्षणाला प्रोत्साहन दिले पाहिजे. भारतातील उच्च शिक्षणात अलीकडच्या काळात लक्षणीय बदल झाला आहे. माहिती आणि दळणवळण तंत्रज्ञानाची उपलब्धता, समाजाची सामाजिक गतिशीलता, या क्षेत्रातील निधीची पद्धत, संशोधनाचे वाढते महत्त्व आणि शिक्षण प्रणालीचे विविधीकरण, या घटकांनी या परिवर्तनाला गती दिली आहे. शैक्षणिक संस्था आणि विद्यापीठांनी या आमूलाग्र बदलाला योग्य रीतीने प्रतिसाद दिला पाहिजे आणि तरुण भारताच्या उच्च शिक्षणाच्या वाढत्या गरजेनुसार स्वतःला जुळवून घेतले पाहिजे. अनेक घटकांद्वारे नियंत्रित असलेल्या एका

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

मोठ्या संस्थेचे संचालन करण्याचा दबाव सांभाळत असतानाच, नाविन्यपूर्ण दृष्टिकोन सादर करण्यात उच्च शिक्षण क्षेत्र एक महत्त्वाची भूमिका बजावते.

शाश्वत विकासाला चालना देण्याचा सर्वात प्रभावी मार्ग म्हणजे सर्व संबंधित घटकांमध्ये जागरूकता निर्माण करणे. जेव्हा विद्यापीठे आणि महाविद्यालये शाश्वत विकासाच्या बाबतीत नेतृत्वाची भूमिका घेतात, तेव्हा या गरजा पूर्ण होऊ शकतात. जागतिक आणि यशस्वी उपायासाठी दूरदृष्टी ठेवून धोरण आखू शकतात. शिक्षण केंद्रे म्हणून, ते विद्यार्थ्यांना हवामान बदल, ऊर्जा कार्यक्षमता, तसेच शाश्वततेच्या व्यापक व्याख्येशी संबंधित समस्या हाताळण्यासाठी शिक्षित आणि सक्षम करू शकतात. प्रत्येक क्षेत्रातील तंत्रज्ञानाच्या विकासामुळे उच्च शिक्षण ही जबाबदारी सहजपणे घेऊ शकते आणि त्याद्वारे समाजाच्या गरजा व आवश्यकतांशी आपली सुसंगतता सिद्ध करू शकते. म्हणूनच, उच्च शिक्षणाने आपली सर्व संसाधने आणि स्वातंत्र्याची भावना मानवतेसाठी आणि समाजासाठी जे सुसंगत आणि आवश्यक आहे, त्याच्या सेवेत लावून एक मूलभूत भूमिका बजावली पाहिजे.

गृहिते –

1) शाश्वत विकासात उच्च शिक्षणाची भूमिका महत्त्वाची आहे.

उद्दिष्ये-

1) शाश्वत विकासात उच्च शिक्षणाची भूमिका समजून घेणे.

2) उच्च शिक्षणात शाश्वत विकास समाविष्ट करण्यातील आव्हाने शोधणे.

संशोधन पद्धती –

प्रस्तुत संशोधन हे जर्नल्स, मासिके, लेखानंमधून प्राप्त केलेल्या दुय्यम माहितीवर आधारित आहे. संशोधनाची रचना वर्णनात्मक प्रकारची आहे. संशोधनाची उद्दिष्टे, विश्लेषण, अभ्यास पद्धती यांचा सखोल अभ्यास करण्यासाठी संशोधनात दुय्यम माहितीचा उपयोग केला आहे.

शाश्वत विकासात उच्च शिक्षणाची भूमिका-

1) मानवी भांडवल निर्मिती: उच्च शिक्षणामुळे कुशल मनुष्यबळ निर्माण होते, जे शाश्वत विकासाच्या प्रक्रियेत आर्थिक वृद्धीसाठी आवश्यक आहे. तांत्रिक आणि व्यावसायिक शिक्षणामुळे रोजगाराच्या नवीन संधी निर्माण होतात, त्यामुळे गरीबी कमी होण्यास आणि जीवनमान सुधारण्यास मदत होते.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

2) संशोधन आणि नाविन्य: विद्यापीठे आणि संशोधन संस्थांमधून नूतनीकरणयोग्य ऊर्जा, पर्यावरणपूरक तंत्रज्ञान आणि कचरा व्यवस्थापन या विषयांवर संशोधन होते. हे संशोधन उत्पादकता वाढवून नैसर्गिक संसाधनांचा कमी वापर करण्यास मदत करते.

3) आर्थिक समानता आणि सामाजिक स्थिरता: उच्च शिक्षण सर्वसमावेशक विकासाला प्रोत्साहन देते. लैंगिक समानता, आरोग्य आणि शिक्षण यांसारख्या विषयांवर जागृती करून, उच्च शिक्षण संस्था सामाजिक समता प्रस्थापित करण्यास मदत करतात, जे शाश्वत विकासाचे एक महत्त्वाचे अंग आहे.

4) धोरणनिर्मितीमध्ये सहभाग: अर्थशास्त्रीय दृष्टिकोनातून, उच्च शिक्षण संस्था सरकारला शाश्वत विकासाची धोरणे आखण्यासाठी आवश्यक डेटा आणि विश्लेषणात्मक आधार पुरवतात.

5) पर्यावरणीय जागृती: उच्च शिक्षणामुळे पर्यावरणाविषयी संवेदनशील पिढी तयार होते, जी उपभोगवादी संस्कृतीकडून शाश्वत जीवनशैलीकडे वळते.

भारताच्या शाश्वत विकास उद्दिष्टांमध्ये उच्च शिक्षण संस्था कळीची भूमिका बजावतात. 2024 च्या आकडेवारीनुसार, टाइम्स हायर एज्युकेशन इम्पॅक्ट रँकिंगमध्ये भारताचे 100 विद्यापीठांसह जागतिक स्तरावर उत्कृष्ट प्रतिनिधित्व आहे . देशात 993 पेक्षा जास्त विद्यापीठे, 39,931 महाविद्यालये असून सुमारे 37.4 दशलक्ष तरुण उच्च शिक्षण घेत आहेत, जे हरित अर्थव्यवस्था आणि शाश्वततेसाठी कौशल्य निर्माण करतात.

शाश्वत विकासात उच्च शिक्षणाची भूमिकेचा उपयोग: उच्च शिक्षण शाश्वत विकासासाठी अनेक प्रकारे उपयुक्त ठरते. विद्यार्थ्यांमध्ये पर्यावरणाबद्दल जागरूकता निर्माण करून त्यांना जबाबदार नागरिक बनवण्याचे काम ते करते. संशोधन आणि विकासाच्या माध्यमातून हरित तंत्रज्ञान, ऊर्जा बचत उपाय आणि संसाधन व्यवस्थापनाच्या नवीन पद्धती विकसित केल्या जातात. याशिवाय, कौशल्याधारित शिक्षणामुळे रोजगारनिर्मिती होते आणि आर्थिक स्थैर्य वाढते. उच्च शिक्षण धोरणनिर्मितीतही मदत करते, कारण तज्ञ आणि संशोधक सरकारला शाश्वत विकासासाठी योग्य उपाय सुचवतात.

शाश्वत विकासात उच्च शिक्षणाची भूमिकेचे महत्त्व: शाश्वत विकास साध्य करण्यासाठी उच्च शिक्षण अत्यंत महत्त्वाचे आहे. ते मानवी भांडवल निर्माण करून आर्थिक प्रगतीला चालना देते. शिक्षणामुळे सामाजिक समता वाढते आणि दुर्बल घटकांना संधी मिळते. पर्यावरण संरक्षणासाठी आवश्यक ज्ञान आणि मूल्ये विद्यार्थ्यांमध्ये रुजवली जातात. दीर्घकालीन विकासासाठी आवश्यक असलेली नवकल्पना, तांत्रिक प्रगती आणि जागतिक स्पर्धात्मकता वाढवण्यात उच्च शिक्षणाचा मोठा वाटा आहे.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

शाश्वत विकासात उच्च शिक्षणाची भूमिकेच्या मर्यादा : उच्च शिक्षणाच्या माध्यमातून शाश्वत विकास साध्य करताना काही अडचणी दिसून येतात. सर्वप्रथम, शिक्षणातील असमानता ही मोठी समस्या आहे. ग्रामीण व शहरी भागांमध्ये उच्च शिक्षणाच्या संधी समान नाहीत. त्यामुळे सर्व घटकांपर्यंत शाश्वत विकासाचे ज्ञान पोहोचत नाही. दुसरे म्हणजे, अनेक शिक्षण संस्थांमध्ये अभ्यासक्रम अद्ययावत नसतात आणि शाश्वत विकासाशी संबंधित विषयांना पुरेसे महत्त्व दिले जात नाही. संशोधनासाठी लागणाऱ्या निधीचा अभावही एक मर्यादा आहे, ज्यामुळे नवकल्पना आणि पर्यावरणपूरक तंत्रज्ञानाचा विकास मर्यादित राहतो. तसेच, शिक्षण आणि उद्योग यांच्यातील समन्वय कमी असल्यामुळे प्रत्यक्ष अंमलबजावणीमध्ये अडथळे निर्माण होतात.

निष्कर्ष: शाश्वत विकास साध्य करण्यासाठी उच्च शिक्षण हे एक प्रभावी साधन आहे. अर्थशास्त्रीय दृष्टीकोनातून ते मानवी भांडवल निर्माण करते, नवोन्मेषाला चालना देते आणि सामाजिक समता वाढवते. त्यामुळे दीर्घकालीन आणि समतोल आर्थिक विकासासाठी उच्च शिक्षण प्रणाली अधिक सक्षम आणि सर्वसमावेशक बनवणे अत्यावश्यक आहे. उच्च शिक्षण आणि शाश्वत विकास यांचा परस्पर संबंध अत्यंत महत्त्वाचा आहे. शाश्वत विकासाचा उद्देश आर्थिक प्रगती, पर्यावरण संरक्षण आणि सामाजिक समता साधणे हा आहे, आणि या उद्दिष्टांच्या पूर्ततेसाठी उच्च शिक्षण महत्त्वाची भूमिका बजावते. उच्च शिक्षण संस्थांद्वारे विद्यार्थ्यांमध्ये ज्ञान, कौशल्ये आणि जबाबदारीची जाणीव विकसित होते, त्यामुळे ते शाश्वत विकासाच्या तत्त्वांचा अवलंब करतात. अर्थशास्त्रीय दृष्टिकोनातून पाहता, उच्च शिक्षण मानवी भांडवलाची निर्मिती करते, त्यामुळे उत्पादनक्षमता वाढते आणि दीर्घकालीन आर्थिक विकास साध्य होतो. तसेच, संशोधन आणि नवकल्पनांच्या माध्यमातून पर्यावरणपूरक तंत्रज्ञानाचा विकास होतो, त्यामुळे नैसर्गिक संसाधनांचा कार्यक्षम वापर शक्य होतो. मात्र, शिक्षणातील असमानता, गुणवत्ता आणि संसाधनांची कमतरता ही काही आव्हाने आहेत. या समस्या दूर केल्यास उच्च शिक्षण अधिक प्रभावीपणे शाश्वत विकास साध्य करण्यात मदत करू शकते. एकंदरीत, उच्च शिक्षण हे शाश्वत विकासासाठी एक महत्त्वपूर्ण साधन असून, समतोल आणि दीर्घकालीन प्रगतीसाठी ते अत्यावश्यक आहे.

संदर्भ-

1) Varadarajan D. B. & Chitra, M. (2023). Environmental Policy: An Overview Economics.
2) Kadam B. J. (2014). Sustainable Development in Indian Economic Perspective.
3) Pandit. V. (2004) Sustainable Economic Growth for India: An Exercise in
4) Macroeconomic Scenario Building. Journal of Quantum Economics.
5) Pooja Prakash Srivastava and Dr.Rashmi Choudhary (May 2021) Economic
6) Growth and Sustainable Development in India.
7) Kanchan Devi (2021), Challenges to Sustainable Development in Context to India.

6) Prof. Laxman. T (November 2022) Challenges of Sustainable Development in Indian Economy – A Study.

7) डॉ. आनंद न्यानेश्वर शिंदे(२०२४), शाश्वत विकासासाठी शिक्षण – सोलापूर.

8) प्रा. कीर्ती चित्ते(२०२५), शाश्वत विकासासाठी शिक्षा – नाशिक.

9) डॉ. टी एम गुरनुले, शाश्वत विकासासाठी शिक्षण – नांदेड.

10) डॉ. एकनाथ मुंडे (2023), भारतातील शाश्वत विकासासाठी शिक्षण- पुणे.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

जागतिकीकरण आणि ज्ञानाची देवाणघेवाण

विकास बाळासाहेब पावसे[1]
संशोधक विद्यार्थी
डॉ.एल.जी.रेटवडे[2]**.**
संशोधक मार्गदर्शक
बाबुरावजी घोलप कॉलेज, सांगावी , पुणे - 27.

सारांश

जागतिकीकरण ही आधुनिक काळातील एक व्यापक सामाजिक-आर्थिक प्रक्रिया आहे ज्यामुळे जगातील विविध देशांमधील परस्पर संबंध अधिक मजबूत झाले आहेत. माहिती तंत्रज्ञान, इंटरनेट, डिजिटल संप्रेषण व्यवस्था आणि आंतरराष्ट्रीय शैक्षणिक सहकार्य यांच्या वाढत्या वापरामुळे ज्ञान, माहिती आणि अनुभव यांची देवाणघेवाण अधिक वेगाने आणि प्रभावीपणे होऊ लागली आहे. उच्च शिक्षण संस्था, संशोधन केंद्रे, आंतरराष्ट्रीय परिषद, सेमिनार तसेच ऑनलाइन शिक्षण मंच यांच्या माध्यमातून ज्ञानाचा प्रसार जागतिक स्तरावर पोहोचत आहे. प्रस्तुत लेखामध्ये जागतिकीकरणामुळे ज्ञान देवाणघेवाणीच्या प्रक्रियेत झालेले बदल, शिक्षण क्षेत्रावर झालेले परिणाम, त्याचे फायदे आणि मर्यादा तसेच भविष्यातील संधी यांचा अभ्यास करण्यात आला आहे. या संशोधनासाठी मुख्यतः दुय्यम माहिती स्रोतांचा वापर करून विश्लेषणात्मक पद्धतीचा अवलंब करण्यात आला आहे.

सूचक शब्द

जागतिकीकरण, ज्ञान देवाणघेवाण, उच्च शिक्षण, माहिती तंत्रज्ञान, संशोधन, डिजिटल शिक्षण

1. प्रस्तावना

आजच्या ज्ञानाधारित समाजात माहिती आणि ज्ञान ही प्रगतीची महत्त्वाची साधने मानली जातात. तंत्रज्ञानातील प्रगतीमुळे जगातील विविध भागांतील लोकांमध्ये संपर्क आणि संवाद अधिक सोपा झाला आहे. यामुळे शिक्षण, संशोधन आणि ज्ञाननिर्मितीच्या प्रक्रियेत मोठे बदल झाले आहेत. जागतिकीकरणामुळे विविध देशांतील विद्यापीठे, संशोधक आणि विद्यार्थी यांच्यात सहकार्य वाढले आहे. संशोधन प्रकल्प, संयुक्त अभ्यासक्रम, आंतरराष्ट्रीय परिषद आणि विद्यार्थी विनिमय कार्यक्रम यांच्या माध्यमातून ज्ञानाचा प्रसार जागतिक

पातळीवर होऊ लागला आहे. परिणामी शिक्षण व्यवस्थेची गुणवत्ता वाढण्यास मदत झाली आहे आणि संशोधन क्षेत्रात नवीन संधी निर्माण झाल्या आहेत.

ज्ञानाची देवाणघेवाण ही आधुनिक शिक्षण व्यवस्थेचा एक महत्त्वपूर्ण घटक बनली आहे. डिजिटल तंत्रज्ञानामुळे माहिती सहज उपलब्ध होत असल्याने विद्यार्थ्यांना आणि संशोधकांना जागतिक स्तरावरील ज्ञान मिळण्याची संधी प्राप्त झाली आहे. त्यामुळे ज्ञानाचा प्रसार अधिक व्यापक स्वरूपात होऊ लागला आहे.

2. जागतिकीकरणाची संकल्पना

जागतिकीकरण म्हणजे विविध देशांमधील आर्थिक, सामाजिक, सांस्कृतिक आणि शैक्षणिक संबंध अधिक दृढ होण्याची प्रक्रिया होय. या प्रक्रियेमुळे वस्तू, सेवा, तंत्रज्ञान आणि ज्ञान यांची देवाणघेवाण सुलभ होते. जागतिकीकरणामुळे जगातील विविध समाजांमध्ये परस्पर अवलंबित्व वाढले आहे.

माहिती आणि संप्रेषण तंत्रज्ञानाच्या झपाट्याने झालेल्या विकासामुळे जागतिकीकरणाला मोठी चालना मिळाली आहे. इंटरनेट, डिजिटल माध्यमे, ऑनलाइन शिक्षण आणि आंतरराष्ट्रीय संशोधन नेटवर्क यांच्या साहाय्याने ज्ञानाचा प्रसार अत्यंत वेगाने होत आहे. त्यामुळे शिक्षण क्षेत्रात नवीन संधी निर्माण होत आहेत आणि संशोधनाची व्याप्ती वाढत आहे.

जागतिकीकरणामुळे शिक्षण प्रणाली अधिक खुली आणि गतिशील बनली आहे. विविध देशांतील शैक्षणिक संस्था परस्पर सहकार्य करून संयुक्त संशोधन प्रकल्प राबवित आहेत. त्यामुळे ज्ञाननिर्मितीची प्रक्रिया अधिक प्रभावी झाली आहे.

3. साहित्याचा आढावा

जागतिकीकरण आणि शिक्षण यांच्यातील संबंधांचा अभ्यास अनेक संशोधकांनी केला आहे. विविध अभ्यासांनुसार जागतिकीकरणामुळे उच्च शिक्षण संस्थांमध्ये आंतरराष्ट्रीय सहकार्य वाढले आहे. संशोधन प्रकल्प, विद्यार्थी विनिमय कार्यक्रम आणि संयुक्त शैक्षणिक उपक्रम यांच्या माध्यमातून ज्ञानाचा प्रसार अधिक व्यापक झाला आहे.

काही संशोधकांच्या मते डिजिटल तंत्रज्ञानामुळे शिक्षण प्रणालीत मोठे परिवर्तन झाले आहे. ऑनलाइन जर्नल्स, ई-लायब्ररी, संशोधन डेटाबेस आणि शैक्षणिक पोर्टल्स यांच्या माध्यमातून संशोधन साहित्य जगभर उपलब्ध झाले आहे. त्यामुळे संशोधकांना विविध देशांतील संशोधनाचा अभ्यास करणे सोपे झाले आहे.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

तसेच जागतिकीकरणामुळे शिक्षण क्षेत्रात गुणवत्ता सुधारण्यास मदत झाली आहे. आंतरराष्ट्रीय मानके, संयुक्त अभ्यासक्रम आणि संशोधन सहकार्य यांमुळे उच्च शिक्षण अधिक स्पर्धात्मक आणि गुणवत्तापूर्ण झाले आहे.

4. संशोधन पद्धती

या लेखासाठी मुख्यतः दुय्यम माहिती स्रोतांचा वापर करण्यात आला आहे. विविध पुस्तके, संशोधन लेख, शैक्षणिक जर्नल्स, सरकारी अहवाल आणि ऑनलाइन स्रोत यांच्या आधारे माहिती संकलित करण्यात आली आहे. संकलित माहितीचे विश्लेषण करून जागतिकीकरणामुळे ज्ञान देवाणघेवाणीवर होणाऱ्या परिणामांचा अभ्यास करण्यात आला आहे.

या अभ्यासात वर्णनात्मक आणि विश्लेषणात्मक पद्धतीचा वापर करण्यात आला आहे. विविध संशोधन निष्कर्षांची तुलना करून शिक्षण क्षेत्रातील बदलांचा अभ्यास करण्यात आला आहे.

5. जागतिकीकरण आणि ज्ञानाची देवाणघेवाण

जागतिकीकरणामुळे ज्ञानाचा प्रसार अधिक जलद आणि व्यापक झाला आहे. इंटरनेट आणि डिजिटल तंत्रज्ञानामुळे जगातील कोणत्याही भागातील माहिती काही क्षणांत उपलब्ध होते. त्यामुळे विद्यार्थ्यांना आणि संशोधकांना नवीन ज्ञान मिळविणे अधिक सोपे झाले आहे.

विद्यापीठे, संशोधन संस्था आणि आंतरराष्ट्रीय परिषदांच्या माध्यमातून विविध देशांतील संशोधक एकत्र येऊन संशोधन करतात. संयुक्त संशोधन प्रकल्पांमुळे ज्ञाननिर्मितीची प्रक्रिया अधिक प्रभावी झाली आहे.

तसेच विद्यार्थी विनिमय कार्यक्रम आणि ऑनलाइन शिक्षण मंच यांच्या माध्यमातून विविध संस्कृती आणि ज्ञान परंपरांचा अभ्यास करण्याची संधी उपलब्ध होते. त्यामुळे शिक्षण अधिक समृद्ध आणि व्यापक बनते.

6. शिक्षण क्षेत्रातील महत्त्व

जागतिकीकरणामुळे शिक्षण क्षेत्रात अनेक सकारात्मक बदल झाले आहेत. विद्यार्थ्यांना जागतिक स्तरावरील ज्ञान सहज उपलब्ध झाले आहे. विविध देशांतील विद्यापीठांमधील सहकार्यामुळे संशोधन प्रकल्प अधिक प्रभावीपणे राबवले जात आहेत.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

यामुळे विद्यार्थ्यांची विचारसरणी अधिक व्यापक बनते. ते जागतिक समस्यांकडे वैज्ञानिक आणि तर्कशुद्ध दृष्टीकोनातून पाहू लागतात. तसेच विविध संस्कृतींचा अभ्यास करण्याची संधी मिळाल्यामुळे विद्यार्थ्यांमध्ये आंतरराष्ट्रीय दृष्टिकोन विकसित होतो.

शिक्षण क्षेत्रात डिजिटल साधनांचा वापर वाढल्यामुळे अध्यापन आणि शिक्षण प्रक्रिया अधिक प्रभावी झाली आहे.

7. जागतिकीकरणाचे फायदे

जागतिकीकरणामुळे शिक्षण आणि संशोधन क्षेत्रात अनेक फायदे झाले आहेत.

१. ज्ञानाचा जलद आणि व्यापक प्रसार होतो.

२. संशोधन आणि नवकल्पनांना प्रोत्साहन मिळते.

३. आंतरराष्ट्रीय सहकार्य वाढते.

४. शिक्षण व्यवस्थेची गुणवत्ता सुधारते.

५. विद्यार्थ्यांना जागतिक स्तरावर संधी उपलब्ध होतात.

६. विविध संस्कृती आणि ज्ञान परंपरांचा अभ्यास करण्याची संधी मिळते.

8. आव्हाने

जागतिकीकरणामुळे काही आव्हाने देखील निर्माण झाली आहेत. विकसित देशांकडे अधिक संसाधने असल्यामुळे विकसनशील देशांना स्पर्धा करावी लागते. काही वेळा स्थानिक संस्कृती आणि परंपरांवर जागतिक संस्कृतीचा प्रभाव पडतो.

तसेच सर्व देशांना समान प्रमाणात ज्ञान आणि तंत्रज्ञानाचा लाभ मिळत नाही. डिजिटल दरी (Digital Divide) हीदेखील एक महत्त्वाची समस्या आहे. ग्रामीण आणि शहरी भागांमध्ये तंत्रज्ञानाच्या उपलब्धतेत असमानता आढळते.

या आव्हानांचा सामना करण्यासाठी शिक्षण व्यवस्थेत समावेशक धोरणे राबविणे आवश्यक आहे.

9. निष्कर्ष

जागतिकीकरणामुळे ज्ञान देवाणघेवाणीची प्रक्रिया अधिक गतिमान आणि प्रभावी झाली आहे. माहिती तंत्रज्ञानाच्या साहाय्याने शिक्षण आणि संशोधन क्षेत्रात मोठे परिवर्तन झाले आहे. विविध देशांमधील सहकार्यामुळे ज्ञाननिर्मिती आणि संशोधनाची व्याप्ती वाढली आहे.

भविष्यात ज्ञानाचा प्रसार अधिक व्यापक करण्यासाठी डिजिटल तंत्रज्ञानाचा प्रभावी वापर करणे आवश्यक आहे. तसेच सर्व समाजघटकांना समान शैक्षणिक संधी उपलब्ध करून देणे महत्त्वाचे आहे. योग्य धोरणे आणि आंतरराष्ट्रीय सहकार्य यांच्या माध्यमातून ज्ञानाधारित समाजाची निर्मिती शक्य होऊ शकते.

संदर्भ :

1 डॉ.बी.आर.जोशी (2015), जागतिकीकरण आणि शिक्षण व्यवस्था, पुणे डायमंड पब्लिकेशन्स.

2.डॉ.सुनील शिंदे (2018), आधुनिक शिक्षण आणि समाज, मुंबई :लोकवाङ्मय गृह.

3.डॉ.आर.एम.जाधव (2016), जागतिकीकरणाचा समाजावर परिणाम,नागपूर :विद्या प्रकाशन

4.University Grants Commission (2020), Higher Education in India: Issues and Challenges, New Delhi.

5 Government of India Ministry of Education (2020)National Education policy, New Delhi.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

शिक्षण आणि शाश्वत विकास : एक अभ्यास

प्रा. डॉ. धनराज सुभाष हाडुळे

सहायक प्राध्यापक, तत्त्वज्ञान विभाग

अगस्ति कला, वाणिज्य व दादासाहेब रूपवते विज्ञान महाविद्यालय, अकोले

ता. अकोले, जि. अहिल्यानगर

Email : dhanrajhadule@gmail.com

Mob. 8275473201

प्रस्तावना :

आजच्या आधुनिक युगात मानवाने विज्ञान, तंत्रज्ञान आणि औद्योगिकीकरणाच्या माध्यमातून मोठी प्रगती केली आहे. परंतु या प्रगतीसोबतच पर्यावरणीय असंतुलन, नैसर्गिक संसाधनांची घट, प्रदूषण आणि हवामान बदल यांसारख्या गंभीर समस्याही निर्माण झालेल्या आहेत. या समस्यांवर उपाय म्हणून "शाश्वत विकास" ही संकल्पना पुढे आली आहे. म्हणून शाश्वत विकास हा आधुनिक जगातील अत्यंत महत्त्वाचा विषय बनला आहे. शाश्वत विकास साध्य करण्यासाठी शिक्षण हा सर्वात प्रभावी आणि मूलभूत घटक आहे. कारण शिक्षणामुळे व्यक्तीमध्ये जाणीव, मूल्ये आणि जबाबदारीची भावना निर्माण होते, जी शाश्वत समाजनिर्मितीसाठी अत्यंत आवश्यक आहे. तसेच सामाजिक आणि आर्थिक समतोल राखण्यासाठी शिक्षणाची भूमिका अत्यंत महत्त्वपूर्ण आहे. शाश्वत विकास म्हणजे वर्तमान पिढीच्या गरजा पूर्ण करताना भविष्यातील पिढ्यांच्या गरजांवर कोणताही विपरीत परिणाम होणार नाही याची काळजी घेणे होय. या उद्दिष्टाची पूर्तता करण्यासाठी शिक्षण हा सर्वात प्रभावी आणि दीर्घकालीन मार्ग मानला जातो.

शाश्वत विकासाची संकल्पना आणि स्वरूप :-

सर्वसामान्य व्यक्तीची अशी समजूत आहे की, आर्थिक विकास झाला म्हणजे सर्व विकास झाला; पण ही समजूत चुकीची आहे. आर्थिकदृष्ट्या विकसित राष्ट्रेही चिरंतन विकासाकडे लक्ष देत नाहीत. त्यामुळे प्रदूषित झालेल्या परिस्थितीत व्यक्तिला राहणे कठीण जाते. व्यक्तिला जीवन जगण्यासाठी स्वच्छ पर्यावरण, स्वच्छ पाणी, प्रदूषणमुक्त हवा आणि आरोग्यदायी वातावरण या गोष्टींची आवश्यकता आहे. विकसित राष्ट्रांना 1970 च्या दरम्यान याची गरज लक्षात आली. जंगलातील वृक्षतोड, कृत्रिम खतांचा वापर, विषारी किटकनाशके, संकरीत बी-बियानांचा वापर, प्लास्टिकचा वापर, इंधनवापर, प्राण्यांचे शोषण, खाण व जंगलातील वनस्पतींचा नाश तसेच प्राण्यांचा बेकायदेशीर नाश, वाळू उत्खनन इत्यादी गोष्टींचा गैरवापर आर्थिक विकासाच्या नावाखाली

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

केला जात आहे व ही साधनसंपत्ती झपाट्याने नष्ट होत आहे. त्याचे पुनर्निर्माण अशक्य आहे. त्यामुळे पर्यावरण संतुलन ढासळले व जागतिक तापमानात बदल झाला. विकसित राष्ट्रांनी या साधनसंपत्तीचा अतिरिक्त वापर केला. या सर्व गोष्टी कमी करण्यासाठी शाश्वत विकासाकडे लक्ष देणे आवश्यक आहे. शाश्वत विकास म्हणजे "भविष्यकालीन पिढ्यांच्या गरजांना कोणत्याही प्रकारचा त्रास न देता सध्याच्या पिढ्यांच्या गरजा जो विकास पूर्ण करतो तो विकास म्हणजे शाश्वत विकास होय." हा विकास देश, धर्म, जात, पंथ, भाषा, लिंग इत्यादी भेद मानत नाही. तसेच तो विकास सर्वांना समान असतो.

शाश्वत विकासाची तत्वे :-

१) आपण ज्या निसर्गाचे घटक आहोत, त्याला विकासाच्या नावाखाली विस्कळीत होऊ देऊ नये. विकास प्रक्रियेबरोबरच नैसर्गिक साधनसंपत्ती ही जतन करून ठेवली पाहिजे.

२) जुन्या व नविन तंत्रज्ञानाचा समन्वय झाला पाहिजे. कारण नविन तंत्रज्ञान हे सर्वसामान्य समस्या सोडवू शकत नाही.

३) पर्यावरणाकडे दुर्लक्ष करून आपले राष्ट्र विकसित करायचे नाही.

४) खरा विकास म्हणजे पर्यावरणात्मक योग्य शाश्वत विकास होय.

५) जंगलाची पुनर्निर्मिती होऊ शकते. परंतु खनिजे व खनिजतेलासंबंधी पुनर्निर्मिती होऊ शकत नाही. त्यामुळे त्याचे जतन करावे.

शाश्वत विकासासाठी शिक्षणाची भूमिका :

१) पर्यावरणीय जागरूकता निर्माण करणे :-

शिक्षणामुळे विद्यार्थ्यांमध्ये पर्यावरणाबद्दल संवेदनशीलता आणि जागरूकता निर्माण होते. नैसर्गिक साधनसंपत्तीचे महत्त्व आणि त्यांचा योग्य वापर कसा करावा हे समजते. प्रदूषण, हवामान बदल, जलसंकट यांसारख्या समस्यांची जाणीव होते. शिक्षणातून वृक्षारोपण, पाणी बचत, कचरा व्यवस्थापन यांसारख्या उपक्रमांची सवय लागते. पर्यावरणपूरक जीवनशैलीचा स्वीकार करण्यास प्रेरणा मिळते. तसेच भावी पिढ्यांसाठी पर्यावरण जतन करण्याची जबाबदारी विद्यार्थ्यांमध्ये विकसित होते.

२) सामाजिक समता आणि न्याय प्रस्थापित करणे :-

शिक्षण समाजातील विषमता कमी करण्यासाठी महत्त्वाची भूमिका बजावते. जाती, धर्म, लिंग यांवर आधारित भेदभाव कमी करण्यास मदत करते. सर्वांना समान संधी मिळावी यासाठी शिक्षण जागरूकता निर्माण

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

करते. मानवी हक्क, समानता आणि न्याय यांची जाणीव विद्यार्थ्यांना होते. शिक्षणामुळे दुर्बल घटकांना सशक्त बनवता येते. यामुळे समाजात समता, बंधुता आणि न्यायाची भावना वाढीस लागते.

३) आर्थिक विकासाला चालना देणे :-

शिक्षणामुळे कौशल्ये आणि ज्ञान विकसित होतात, ज्यामुळे रोजगाराच्या संधी वाढतात. उद्योग, तंत्रज्ञान आणि नवकल्पनांना चालना मिळते. उत्पादकता वाढल्यामुळे देशाच्या आर्थिक प्रगतीला मदत होते. उद्योजकता आणि स्वावलंबनाची भावना शिक्षणातून निर्माण होते. शिक्षणामुळे गरिबी कमी करण्यास आणि जीवनमान सुधारण्यास मदत होते. त्यामुळे शाश्वत आणि संतुलित आर्थिक विकास साध्य होतो.

४) जबाबदार नागरिक घडविणे :-

शिक्षणामुळे नागरिकांमध्ये कर्तव्यभावना आणि सामाजिक जबाबदारी विकसित होते. लोकशाही मूल्यांची जाणीव आणि पालन करण्याची सवय लागते. पर्यावरण, समाज आणि देशाबद्दल उत्तरदायित्वाची भावना वाढते. कायदे आणि नियमांचे पालन करण्याची वृत्ती तयार होते. शिक्षणामुळे नागरिक सक्रियपणे सामाजिक कार्यात सहभागी होतात. ज्यामुळे समाज अधिक सुदृढ आणि सुसंस्कृत बनतो.

५) नैतिक मूल्ये आणि जीवनदृष्टी विकसित करणे :-

शिक्षण विद्यार्थ्यांमध्ये प्रामाणिकपणा, सहकार्य, सहानुभूती यांसारखी नैतिक मूल्ये रुजवते. योग्य-अयोग्य याचा विचार करण्याची क्षमता वाढते. जीवनातील समस्यांना सकारात्मक दृष्टीकोनातून पाहण्याची वृत्ती विकसित होते. शिक्षणामुळे व्यक्तिमत्त्व विकास घडतो आणि आत्मविश्वास वाढतो. समाजात शांतता आणि सद्भावना टिकवण्यासाठी नैतिक मूल्ये महत्त्वाची ठरतात. त्यामुळे शाश्वत आणि संतुलित जीवन जगण्याची दिशा मिळते.

शिक्षण आणि शाश्वत विकास यांचा संबंध :

शिक्षण आणि शाश्वत विकास यांचा संबंध अत्यंत निकटचा आहे. शिक्षणामुळे व्यक्तीमध्ये पर्यावरणाबद्दल जागरूकता निर्माण होते. विद्यार्थ्यांना प्रदूषण, जलसंकट, हवामान बदल, जैवविविधता यांसारख्या समस्यांची सखोल माहिती मिळते आणि त्यावर उपाय शोधण्याची क्षमता विकसित होते. उदाहरणार्थ, वृक्षारोपण, पाण्याची बचत, ऊर्जा संवर्धन यांसारख्या कृतींमधून विद्यार्थी प्रत्यक्ष सहभाग घेतात. अशा प्रकारे शिक्षणामुळे पर्यावरणपूरक जीवनशैली विकसित होते.

शिक्षण सामाजिक विकासातही महत्त्वाची भूमिका बजावते. समानता, सहिष्णुता, मानवाधिकार आणि सामाजिक न्याय यांसारखी मूल्ये विद्यार्थ्यांमध्ये रुजवली जातात. त्यामुळे समाजात एकात्मता, शांतता आणि सहकार्याची भावना वाढीस लागते. शाश्वत विकासासाठी सामाजिक स्थैर्य अत्यावश्यक आहे आणि ते

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

शिक्षणामुळेच शक्य होते. विविध संस्कृती, परंपरा आणि जीवनशैलींचा आदर करण्याची वृत्ती शिक्षणातून विकसित होते, ज्यामुळे समाज अधिक समृद्ध आणि संतुलित बनतो.

आर्थिक विकासाच्या दृष्टीनेही शिक्षण महत्त्वाचे आहे. शिक्षणामुळे लोकांना संसाधनांचा योग्य वापर करण्याची सवय लागते. टिकाऊ उत्पादन आणि उपभोग यांची जाणीव निर्माण होते. त्यामुळे आर्थिक प्रगती करताना पर्यावरणाचे नुकसान टाळता येते. शिक्षणामुळे रोजगाराच्या संधी वाढतात आणि आर्थिक स्थैर्य प्राप्त होते, जे शाश्वत विकासासाठी आवश्यक आहे.

United Nations ने शाश्वत विकासाला जागतिक पातळीवर महत्त्व दिले असून, UNESCO ने "Education for Sustainable Development (ESD)" या संकल्पनेद्वारे शिक्षणाच्या माध्यमातून शाश्वत विकास साध्य करण्याचा मार्ग सुचवला आहे. शिक्षणामुळे केवळ माहिती मिळत नाही, तर व्यक्तीच्या विचारसरणीत, वर्तनात आणि मूल्यांमध्ये सकारात्मक बदल घडून येतो.

भारतातील शाश्वत विकासासाठी शिक्षण :

भारतामध्येही शिक्षणाच्या माध्यमातून शाश्वत विकास साध्य करण्यासाठी विविध प्रयत्न केले जात आहेत. त्यातील काही महत्त्वपूर्ण उपक्रम पुढीलप्रमाणे सांगता येतील.

१) राष्ट्रीय शैक्षणिक धोरण 2020 :-

या धोरणामध्ये सर्वसमावेशक, बहुआयामी आणि कौशल्याधारित शिक्षणावर भर देण्यात आला आहे. विद्यार्थ्यांमध्ये विचारशक्ती, सर्जनशीलता आणि समस्या सोडवण्याची क्षमता विकसित करण्याचा उद्देश आहे. स्थानिक ज्ञान, पर्यावरण शिक्षण आणि डिजिटल शिक्षणालाही प्रोत्साहन दिले आहे. त्यामुळे शिक्षण अधिक उपयुक्त आणि भविष्योन्मुख बनते.

२) स्वच्छ भारत अभियान :-

या अभियानाचा मुख्य उद्देश स्वच्छता राखणे आणि सार्वजनिक आरोग्यात सुधारणा करणे हा आहे. लोकांमध्ये स्वच्छतेबद्दल जागरूकता निर्माण करून उघड्यावर शौचास जाण्याची प्रथा कमी करण्यात आली आहे. शाळा आणि गावांमध्ये स्वच्छता उपक्रम राबवले जात आहेत. यामुळे पर्यावरण आणि आरोग्य दोन्ही सुधारते.

३) जल संवर्धन मोहिमा :

पाण्याचे महत्त्व लक्षात घेऊन विविध जलसंवर्धन उपक्रम राबवले जातात. पावसाचे पाणी साठवणे, पाण्याचा योग्य वापर आणि जलस्रोतांचे संरक्षण यावर भर दिला जातो. या मोहिमांमुळे पाण्याची टंचाई कमी करण्यास मदत होते. तसेच लोकांमध्ये पाणी वाचवण्याची सवय निर्माण होते.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

४) हरित शाळा उपक्रम :

या उपक्रमाद्वारे शाळांमध्ये पर्यावरणपूरक सवयी विकसित केल्या जातात. विद्यार्थ्यांना वृक्षारोपण, कचरा व्यवस्थापन आणि ऊर्जा बचतीबद्दल शिक्षण दिले जाते. शाळा परिसर अधिक स्वच्छ आणि हरित बनवण्यावर भर असतो. त्यामुळे विद्यार्थ्यांमध्ये पर्यावरणाबद्दल जबाबदारीची भावना वाढीस लागते.

५) शालेय स्तरावर पर्यावरण शिक्षण :

शालेय स्तरावर पर्यावरण शिक्षणाद्वारे विद्यार्थ्यांना निसर्ग, पर्यावरण संरक्षण आणि शाश्वत जीवनशैली याबद्दल माहिती दिली जाते. यामध्ये वृक्षारोपण, पाणी बचत, कचरा व्यवस्थापन यांसारख्या उपक्रमांचा समावेश असतो. विद्यार्थ्यांमध्ये पर्यावरणाबद्दल जागरूकता आणि जबाबदारीची भावना विकसित केली जाते. तसेच प्रत्यक्ष कृतीतून शिकण्यावर भर दिला जातो, ज्यामुळे पर्यावरणपूरक सवयी लहानपणापासून रुजतात.

अशा प्रकारे हे सर्व उपक्रम शिक्षणाद्वारे शाश्वत विकासाची पायाभरणी करतात.

शिक्षण आणि शाश्वत विकासाच्या मार्गातील अडचणी :

शिक्षण आणि शाश्वत विकासाच्या मार्गात काही अडचणी दिसून येतात, त्या पुढीलप्रमाणे..

१) शिक्षणाचा अभाव आणि निरक्षरता :

अनेक लोक अजूनही मूलभूत शिक्षणापासून वंचित आहेत, त्यामुळे त्यांना शाश्वत विकासाची संकल्पना समजत नाही. निरक्षरतेमुळे जागरूकता आणि निर्णयक्षमता कमी होते.

२) गरिबी आणि आर्थिक विषमता :

गरिबीमुळे लोकांचे लक्ष मूलभूत गरजांकडे अधिक असते, त्यामुळे शिक्षणाकडे दुर्लक्ष होते. आर्थिक विषमतेमुळे सर्वांना समान शिक्षणाच्या संधी मिळत नाहीत.

३) पर्यावरणाबद्दल अज्ञान :

लोकांना पर्यावरण संरक्षणाचे महत्त्व पुरेसे माहित नसते. त्यामुळे नैसर्गिक साधनसंपत्तीचा अयोग्य वापर होतो आणि पर्यावरणीय समस्या वाढतात.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

४) तंत्रज्ञानाचा असमान वापर :

काही भागांमध्ये आधुनिक तंत्रज्ञान उपलब्ध असते, तर काही ठिकाणी त्याचा अभाव असतो. यामुळे डिजिटल शिक्षणात असमानता निर्माण होते.

५) ग्रामीण आणि शहरी भागातील तफावत :

शहरी भागात शिक्षणाच्या सुविधा अधिक चांगल्या असतात, तर ग्रामीण भागात त्या मर्यादित असतात. त्यामुळे शिक्षणाची गुणवत्ता आणि संधींमध्ये फरक पडतो.

६) शिक्षकांचे अपुरे प्रशिक्षण :

अनेक शिक्षकांना आधुनिक शिक्षणपद्धती आणि तंत्रज्ञानाचे पुरेसे प्रशिक्षण नसते. यामुळे विद्यार्थ्यांना गुणवत्तापूर्ण शिक्षण मिळण्यात अडथळे येतात.

७) ग्रामीण भागात सुविधाचा अभाव :

ग्रामीण भागात शाळा, वाचनालये, इंटरनेट यांसारख्या मूलभूत सुविधांचा अभाव असतो. त्यामुळे विद्यार्थ्यांच्या शिक्षणावर नकारात्मक परिणाम होतो.

८) पारंपरिक शिक्षण पद्धती :

जुनी आणि रटाळ शिक्षणपद्धती अजूनही वापरली जाते. त्यामुळे विद्यार्थ्यांमध्ये सर्जनशीलता आणि विचारशक्ती विकसित होण्यास अडथळे येतात.

वरील सर्व आव्हाने दूर केल्याशिवाय शाश्वत विकास साध्य होऊ शकत नाही.

शाश्वत विकासाचे मार्ग :-

निसर्गाचा विचार न करता फक्त आर्थिक विकास करणे हे उद्दीष्ट समोर ठेवल्यामुळे ही स्थिती निर्माण झाली आहे. त्यामुळे वर्तमानकाळात व भविष्यकाळात शाश्वत विकास करण्यासाठी पुढील उपाययोजना सांगितलेल्या आहेत.

१. नैसर्गिक साधनसंपत्तीचे शोषण होऊ नये. यासाठी विविध तंत्रज्ञान वापरावे व संस्था उभाराव्यात.

२. पर्यावरणाचे घटक असणाऱ्या घटकांचे संरक्षण व संवर्धन करावे.

३. पर्यावरणाच्या संरक्षणाची जबाबदारी त्या त्या परिसरातील लोकांनी स्वीकारावी.

४. खनिज तेलाऐवजी सौर ऊर्जा व पवन ऊर्जा वापरावी.

५. गोर-गरिबांसाठी प्रभावी उपाययोजना कराव्यात.

६. पर्यावरण जणजागृती कार्यक्रम राबवावेत.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

थोडक्यात असे म्हणता येईल की, ज्या विकासात नैसर्गिक साधनसंपत्तीचे संरक्षण होते. तोच खरा शाश्वत विकास होय.

याशिवाय शाश्वत विकासासाठी शिक्षण अधिक प्रभावी करण्यासाठी खालीलप्रमाणे काही उपाय आवश्यक आहेत.

१. सर्वांसाठी दर्जेदार आणि समान शिक्षण उपलब्ध करणे.

२. अभ्यासक्रमात ESD चा समावेश करणे.

३. पर्यावरण शिक्षण अनिवार्य करणे.

४. कौशल्याधारित आणि रोजगाराभिमुख शिक्षणाला प्रोत्साहन देणे.

५. डिजिटल शिक्षणाचा विस्तार करणे.

७. शिक्षकांचे प्रशिक्षण आणि सक्षमीकरण करणे

निष्कर्ष :

शाश्वत विकासासाठी शिक्षण हे आजच्या काळाची गरज आहे. शिक्षण आणि शाश्वत विकास हे एकमेकांशी घट्ट जोडलेले आहेत. शिक्षणामुळे व्यक्तीमध्ये जाणीव, कौशल्ये आणि मूल्ये निर्माण होतात, ज्यामुळे पर्यावरणाचे संरक्षण, सामाजिक समता आणि आर्थिक प्रगती साध्य होते. त्यामुळे शाश्वत विकासासाठी शिक्षण हा पाया आहे असे म्हणणे योग्य ठरेल. प्रत्येक देशाने आणि समाजाने शिक्षणाला प्राधान्य देऊन शाश्वत भविष्य निर्माण करण्यासाठी प्रयत्न करणे ही काळाची गरज आहे. अशा प्रकारे योग्य धोरणे आणि शिक्षणाच्या माध्यमातून आपण एक शाश्वत भविष्य घडवू शकतो.

संदर्भ :

1. Yadav Harish Kumar, *'Education for Sustainable Development'*, Redshine Publication, New Delhi, 2024
2. Goel Sugandha & Sharma Nishi, *'Education for Sustainable Development (ESD)'*, IBP Books, New Delhi, 2020
3. Bhave Asawari, *'Education for Sustainable Development and Environmental Education'*, Success Publications, Pune, 2016
4. Mete Jayanta & Bose Piyali, *'Environmental Education Towards Sustainable Development'*, Redshine Publication, New Delhi, 2022
5. Roy Rajarshi, *'Education for Sustainable Development'*, Shipra Publications, New Delhi, 2014
6. Kuvar Sachin, *'Ecology, Environment and Sustainable Development'*, Mahi Publication, Ahmednagar, 2024

7. लोणकर वामन & राऊत स्वाती, *'पर्यावरण शिक्षण व शाश्वत विकास'*, ठाकूर पब्लिकेशन प्रा. लि., नागपूर, 2024

8. *शाश्वत विकास व पर्यावरण शिक्षण*, (B.Ed.) अभ्यासक्रम, निराली प्रकाशन, पुणे, २०१८

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

SYNTHESIS OF HIGHLY CONDUCTIVE POLYMER PEDOT: PSS BY SURFACTANT TEMPLATES: AN INNOVATIVE APPROACH

Akshay R. Mundhe[1*], Rohit C. Muthe[2], Ashwini S. Gandal[3]
Department of Chemistry,
Adv. M.N. Deshmukh Arts, Commerce and Science College Rajur, Tal. Akole Dist. Ahilyanagar, India
akshaymundhe02@gmail.com

Abstract:

Conductive polymers have attracted considerable attention due to their unique electrical and optical properties for applications in flexible electronics, sensors, and energy devices. In this study, highly conductive poly(3,4-ethylenedioxythiophene): poly (styrene sulfonate) (PEDOT: PSS) nanoparticles were synthesized through a facile chemical oxidative polymerization approach using sodium persulfate as an oxidizing agent. The influence of key synthesis parameters including EDOT: PSS weight ratio, oxidant concentration, and surfactant-assisted nano-templating on the structural, electrical, and morphological properties of PEDOT: PSS was systematically investigated. Surfactants such as CTAB, SDS, and Triton X-100 were employed to control micelle formation and particle morphology during polymerization. Structural characterization using FT-IR, Raman spectroscopy, XRD, and XPS confirmed successful polymer formation and doping interactions between PEDOT and PSS chains. FE-SEM analysis revealed spherical nanoparticles with nanoscale dimensions, indicating surfactant-directed self-assembly. The optimized synthesis condition (EDOT: PSS = 1:11 and EDOT: $Na_2S_2O_8$ = 1:2) in the presence of Triton X-100 resulted in enhanced charge carrier mobility and significantly improved electrical conductivity. The highest conductivity achieved was approximately 1879 S cm^{-1}, demonstrating the effectiveness of surfactant-assisted structural tuning. This study highlights a scalable strategy for tailoring PEDOT: PSS nanostructures with superior conductivity, offering promising potential for applications in flexible electronics, organic photovoltaic devices, and high-performance electrochemical sensors.

Keywords: Conductive polymers, energy devices, nanoparticles, Surfactants.

1. Introduction:

Conductive polymers (CPs) are organic polymers that are different from typical polymers because they can conduct electricity through their conjugated structures, consisting of alternating double (p) bonds and single (s) bonds along the CP chains.1 CPs have sp2 hybridization in their backbones, in which the p-orbital in each atom is perpendicular to the plane of the polymer chain but parallel to each other, allowing electron delocalization along the polymer chains.2 The first conductive polyacetylene was discovered in 1977,3 and since then, many CPs have been intensively investigated. Some common and interesting CPs include

polypyrrole (PPy), polyaniline (PANI), polythiophene (PT), trans-polyacetylene, poly(p-phenylene vinylene), and poly(3,4-ethylenedioxythiophene) (PEDOT).4 CPs have many advantageous properties such as chemical diversity, low density,fexibility, corrosion resistance, controllable morphology, and tunable conductivity.5,6 Therefore, CPs are utilized in many applications, such as polymer light-emitting diodes,7 organic transistors,8 actuators,9 anti-static coatings, sensors, batteries, solar cells,10 and drug delivery.11 Poly(3,4-ethylenedioxythiophene) (PEDOT) is one of most studied conductive polymers owing to its relatively high electrical conductivity and electro-optical properties. PEDOT can be synthesized via both chemical oxidative polymerization and electrochemical polymerization. However, chemical oxidative polymerization provides a higher yield with no special setup required.12 Although PEDOT has high electrical conductivity, it is insoluble in water, making it difficult to process. This problem is overcome by using a polyelectrolyte, poly(- styrene sulfonic acid) (PSS), which acts as a dopant and stabilizer for PEDOT through charge balance.13 Poly(3,4-ethylenedioxythiophene):poly(styrene sulfonate) (PEDOT:PSS) is a PEDOT derivative, which has higher electrical conductivity as compared to other CPs. Moreover, it has other useful properties, such as high transparency, low thermal conductivity, low density, good flexibility, and high thermal stability. In general, PEDOT: PSS is used in various electrical and optical devices, such as thin film transistors, light-emitting diodes, sensors, and photovoltaics. The electrical conductivity of PEDOT:PSS can be enhanced by solvent treatment,18 adding surfactant, and varying the PSS concentration.20 Ouyang et al. investigated the effect of organic solvent treatment using secondary dopants, such as acetonitrile (ACN), 4-methoxyphenol, N,N-dimethylacetamide (DMAc), N-methyl-2-pyrrolidone (NMP), ethylene glycol (EG), and dimethyl sulfoxide (DMSO) to increase the electrical conductivity of the PEDOT:PSS film. The highest electrical conductivity of a PEDOT:PSS film treated with DMSO was 200 S cm^{-1}.18 Oh et al. studied the effect of Triton X-100 (non-ionic surfactant) on the electrical conductivity of PEDOT:PSS films, which increased from 0.85 _ 0.08 to 882 _ 75 S cm^{-1} at a Triton X-100 concentration of 1.0 wt%.19 Horri et al. studied the effect of EDOT : PSS weight ratio on the electrical conductivity of PEDOT:PSS films, and an EDOT : PSS weight ratio of 1 : 2.3 provided the highest electrical conductivity of 700 S cm^{-1}.20 Alternatively, PEDOT:PSS can be prepared in powder form, which can be subsequently modified and processed for various applications, such as proton exchange membrane fuel cells, actuators,22 and sensors.23 Lefebvre et al. studied the effect of the PEDOT:PSS weight ratio in the range of 1 : 2.5 to 1 : 7.5, where the electrical conductivity of the PEDOT:PSS powder varied from 0.3 to 1.3 S cm^{-1}.24 Wichaiansee et al. synthesized PEDOT:PSS powder via chemical oxidative polymerization at room temperature using sodium persulfate ($Na_2S_2O_8$) as the oxidizing agent and ferric sulphate (Fe2(SO4)3) as the catalyst. The synthesized PEDOT: PSS powder possessed electrical conductivity of 27.5 _ 0.6 S cm^{-1}. Chanthanont et al. synthesized PEDOT: PSS powder using $Na_2S_2O_8$ as the oxidizing agent and Fe2(SO4)3 as the catalyst in aqueous solution at room temperature, and the electrical conductivity of the PEDOT: PSS powder was determined to be 11.69 _ 0.006 S cm^{-1}. In summary, it can be noted that PEDOT: PSS in the powder form has relatively lower electrical

conductivity than that of its Films, as previously reported. Herein, we report the synthesis of PEDOT: PSS nanoparticles with high electrical conductivity via chemical oxidative polymerization in aqueous solution at room temperature. The effects of the EDOT: PSS weight ratio, EDOT: $Na_2S_2O_8$ mole ratio, and surfactant type and concentration on the properties of PEDOT: PSS were systematically investigated. The PEDOT: PSS powder samples were characterized via Fourier transform infrared spectroscopy (FT-IR), Raman spectroscopy (Raman), and wide-angle X-ray spectroscopy (XRD) to determine their chemical structure, X-ray photoelectron spectroscopy (XPS) to Analyze their element contents, UV-Vis spectrophotometry (UV-Vis) to determine their doping state, and field-emission scanning electron microscopy (FE-SEM) to determine their particle shape and size. Thermogravimetric analysis (TG-DTA) was used to determine their thermal stability. It was found that the PEDOT: PSS powder with the EDOT: PSS weight ratio of 1: 11, EDOT: $Na_2S_2O_8$ mole ratio of 1: 2, and Triton X-100 at the concentration of 2.5CMC possessed the highest electrical conductivity of 1879.49 - 13.87 S cm^{-1} with the corresponding spherical particle size of 56.77 - 5.54 nm, values not previously obtained to date.

2. Experimental:

2.1 Materials

3,4-Ethylenedioxythiophene (EDOT, 97% purity) monomer, poly (styrene sulfonate) (PSS, 99% purity) with Mw of 75 000 gmol_1, hexadecyltrimethylammonium bromide (CTAB, $96% purity), and sodium persulfate (Na2S2O8, $98% purity) were purchased from Sigma Aldrich. Sodium dodecylsulfate (SDS, $99% purity) and polyoxymethylene octyl phenyl ether (Triton X- 100, $99% purity) were purchased from Omnipur. Methanol (>99.8% purity) and acetone (99.5% purity) were purchased from RCI Labscan. Distillated water was used as the solvent in the synthesis. All reagents were of analytical reagent grade.

2.2 Synthesis of PEDOT: PSS

To investigate the effect of the EDOT : PSS weight ratio, 0.5 g of EDOT was mixed with PSS ranging from 0.5 g to 6.5 g (weight ratios of 1–13), where the $Na_2S_2O_8$ content as the oxidant was fixed at 0.8335 g to give the EDOT : $Na_2S_2O_8$ mole ratio of 1 : 1. The ingredients were dissolved in 100 mL of DI water, then the solution was stirred for 24 h at room temperature. The precipitate was collected by centrifugation at 9000 rpm, rinsed with a mixed solution of acetone: methanol with a volume ratio of 3: 20,25 and then dried in an oven at 60 degrees for 24 h. To determine the effect of the EDOT: $Na_2S_2O_8$ mole ratio, the synthesis procedure was the same as before. 0.83, 1.25, 1.67, 2.08, 2.50, and 3.33 g of $Na_2S_2O_8$ were added to 0.5 g of EDOT to give the EDOT: $Na_2S_2O_8$ mole ratios of 1: 1, 1: 1.5, 1: 2, 1: 2.5, 1: 3, 1: 4, and the EDOT: PSS weight ratio was fixed at 1: 11 (0.5 g: 5.5 g). To study the effect of surfactant type, namely CTAB, SDS, and Triton X-100, and concentration, each surfactant (0.084 g, 0.721 g, 0.141 g, respectively) was added to 100 mL of distilled water and stirred for 1 h to from a surfactant solution at 2.5CMC. Then 0.5 g of EDOT was added in the surfactant solution, which was continuously stirred for 1 h.

Then PSS (5.5 g) was added to the above solution, and it was stirred for 1 h before the $Na_2S_2O_8$ oxidant (1.67 g) was added. The EDOT: PSS weight ratio was fixed at 1: 11 and the EDOT: $Na_2S_2O_8$ mole ratio was 1: 2. The solution was stirred continuously for 24 h at room temperature, and the colour of the solution changed from clear to dark blue. The precipitate was centrifuged at 9000 rpm and then washed with a solution of acetone: methanol at the volume ratio of 3: 20. Finally, the precipitate was dried in an oven at 60 _C for 24 h. Next, the PEDOT:PSS precipitate was ground in a mortar by hand for 3 min to obtain the PEDOT:PSS powder with smaller particle sizes, which was further modified for characterization.26 Lislie et al. reported that grinding PPy with a mortar and pestle for 10 min did not significantly change its electrical conductivity.26 However, Fufang et al. reported that the electrical conductivity of PPy decreased by 21% and the particle size decreased by 26% after grinding in a mortar for 1 h.

2.3 Characterization of PEDOT: PSS nanoparticles

The critical micelle concentration (CMC) of PSS was determined by measuring its surface tension using a tensiometer (Kruss/ Easydyne tensiometer, K20) with the Wilhelmy plate mode at 23 degrees. PSS was dissolved in deionized water at various EDOT: PSS weight ratios. The CMC of PSS was found to be 7 – 10.5 mol L^{-1}. The functional group analysis was carried out via Fourier transformed infrared spectroscopy, FTIR (Thermo Nicolet, Nexus 670). All spectra were recorded in the wavenumber range of 400–4000 cm^{-1}, with 32 scans and a resolution of 4 cm^{-1}. The PEDOT: PSS samples were mixed with background KBr powder and compressed using a hy-draulic press machine. The chemical and structural information of the PEDOT: PSS powder were identified via Raman spectroscopy (Bruker, Ram II) with a laser source at 1064 nm and power of 22 mW. All spectra were recorded in the wavenumber range of 400– 4000 cm^{-1}, with 800 scans and a resolution of 4 cm^{-1}. The PEDOT: PSS crystalline structure was identified via wide angle X-ray spectroscopy, XRD (Rigaku/Smart lab), at a scan step of 0.02_ and scan speed of 5_ min_1 in the 2q range of 5_ to 70_. The Cu-Ka radiation source was operated at 40 kV/30 mA. The PDLX 2 so far aware was used to Analyze the PEDOT: PSS XRD patterns. The element analysis was carried out via X-ray photoelectron spectroscopy, XPS (Kratos, Axis Ultra DLD), using a monochromatized Al Ka radiation source and recorded at the analyzer pass energy of 160 eV for the survey scan, and at 40 eV for the high-resolution scan. All spectra were corrected by using the reference C 1s (binding energy of 284.8 eV). The Casa-XPS software was used for the interpretation of the XPS spectra. The doping state and optical band gap of PEDOT: PSS was identified via UV-Vis spectrophotometry, UV-Vis (Tecan, The Infinite® 200 PRO NanoQuant). The PEDOT: PSS powders were dissolved in deionized water and filtered using a nylon filter. Deionized water was used as the reference. The i-Control so far - aware was used to determine the UV adsorption of the PEDOT: PSS solutions. The band gap energy was calculated using the Tau (1):28 ahn ¼ A(hn _ Eg)n (1) where a is the adsorption coefficient, hn is the photon energy (eV), h is Plank's constant, v is the frequency (s_1), A is a constant, Eg is the band gap energy (eV), and n is equal to 0.5 for direct transitions. The adsorption coefficient (a) was calculated from the Beer–Lambert's relation (2):29 a ¼ 2.303Ab/I (2) where, Ab is the absorbance and I is the sample path length. The extrapolation of the linear line from the plot between (ahn)2 on the y axis and hn on

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

the x axis gives Eg. The morphology of PEDOT: PSS was identified via field emission scanning electron microscopy, FE-SEM (Hitachi, S- 4800), operating at 5 kV/10 mA at a magnification of 100 000. Each sample was distributed on the sample holder with a carbon adhesive tape and coated with a thin layer of platinum before the measurement. The thermal analysis was carried out using a thermogravimetric analyzer, TG-DTA (Perkin Elmer, TGA model 7). 4 to 8 mg of each sample was loaded into an aluminium pan. The sample was scanned from 30 degree C to 800 degree C at a heating rate of 10 degree C min^{-1} under a nitrogen flow. The electrical conductivity was measured using an electrometer (Keithley, model 17A) at room temperature in air. A custom-built two-point probe was used as a mixture for each PEDOT: PSS pellet. The graph between I (y-axis) and V (x-axis) was plotted to obtain the I–V slope, which was used to calculate the electrical conductivity according to equation (3)

$$s ¼ I/KVt ¼ (I–V) slope/Kt……. (3)$$

where, I is the current (A), V is the applied voltage (V), t is the sample thickness (cm), and K is the correction factor calculated using a silicon wafer as the reference. PEDOT: PSS pellets with 0.7 - 0.3 mm thickness and 1.3 cm diameter were prepared by compressing the PEDOT: PSS powder with a hydraulic press machine.

3. Results and discussion

The PEDOT: PSS powder was synthesized via chemical oxidative polymerization following the procedure .In the initial step, $Na_2S_2O_8$ as the oxidant dissociates into sodium ions and a persulfate ion, where the persulfate ion can homolytically dissociate into sulfate radicals in aqueous solution, In the oxidation step, an EDOT monomer is oxidized to an EDOT radical cation by the sulfate radical, leading to the formation of sulfate anions, For the propagation and doping step, the coupling of EDOT radical cations generates two protons, which are removed in this step. Simultaneously, the PSS and sulfate ions acting as dopants can interact with the oxidized PEDOT chains during the polymerization. The sodium ion from the oxidant can also react with the PSS chains, as illustrated.

3.1 Structural conformation of PEDOT: PSS

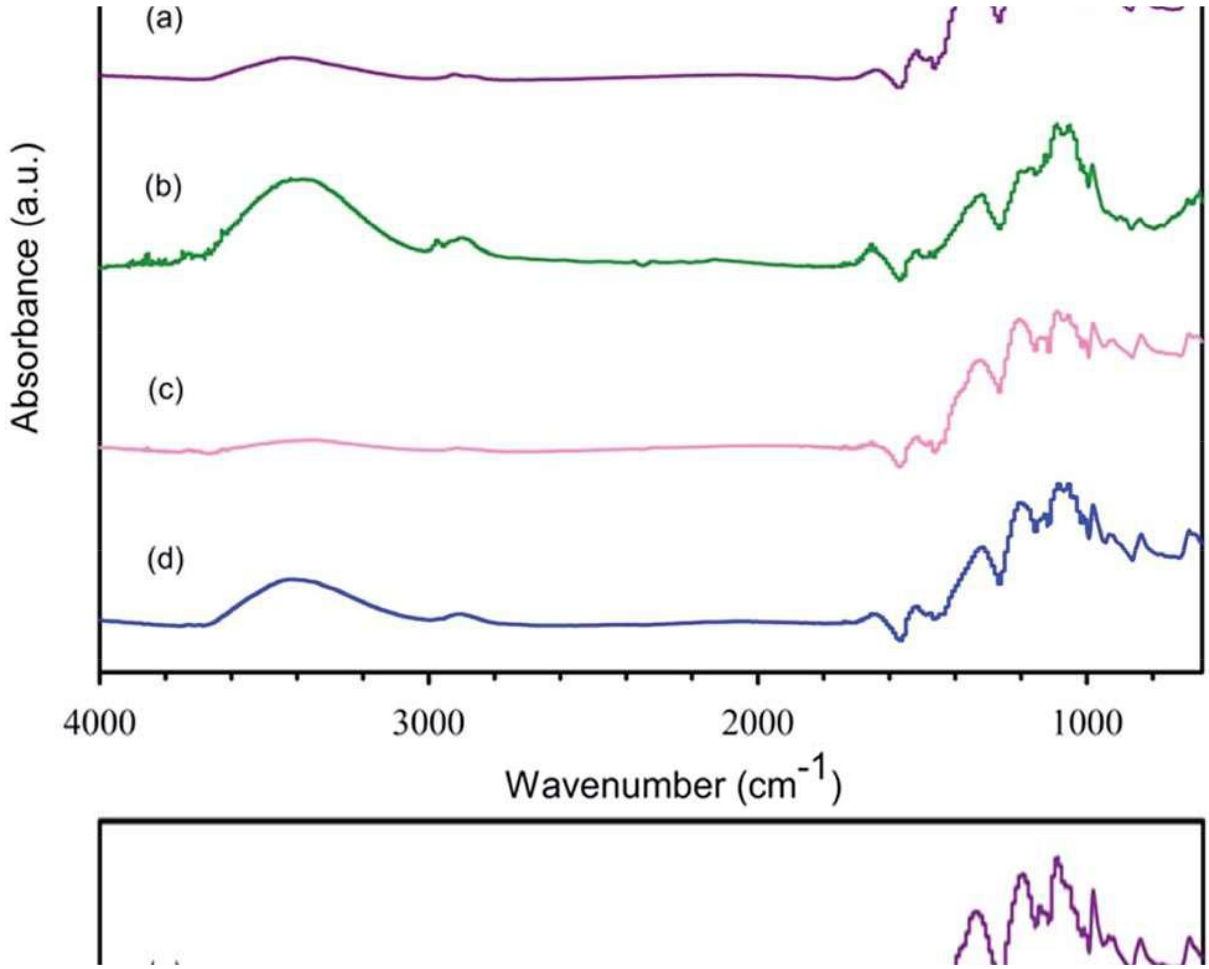
3.1.1 FTIR analysis

The functional groups of PEDOT: PSS synthesized under various conditions were characterized via FTIR. The FTIR spectrum of PEDOT: PSS, at the EDOT: PSS weight ratio of 1: 11 and EDOT: $Na_2S_2O_8$ mole ratio of 1: 2 shows peaks at 1640 and 1518 cm^{-1}, which are assigned to the C]C stretching in the aromatic rings of PSS and the C]C stretching in the thiophene ring of PEDOT,34 respectively. The peak at 1340 cm^{-1} indicates the C–C stretching from the thiophene ring of PEDOT.34 The symmetric stretching and antisymmetric stretching of S]O can be seen at 1198 and 1055 cm^{-1}, respectively, belonging to PSS and $SO4^{2-}$ from the oxidant. The peaks at 1145 and 983 cm^{-1} can be attributed to the S–O stretching in PSS and $SO4^{2-}$ from the oxidant and the S–phenyl bond in PSS, respectively. The three peaks at 936, 840, and 691 cm^{-1} correspond to the C–

S stretching of the thiophene ring in PEDOT.35 The two peaks at 1144 and 1092 cm^{-1} are corresponded to the C–O stretching of PEDOT. The peaks at 3415, and 2921 cm^{-1} correspond to the O–H stretching of PSS and C–H stretching of PEDOT and PSS, respectively, resulting from PSS incorporated in the PEDOT chain. For the PEDOT: PSS synthesized without surfactant at various. EDOT: PSS weight ratios and EDOT : $Na_2S_2O_8$ mole ratios, their FTIR spectra showed the same functional groups as that with the EDOT : PSS weight ratio of 1 : 11 and EDOT : $Na_2S_2O_8$ mole ratio of 1 : 2. The FTIR spectra of the synthesized PEDOT:PSS are similar to the PEDOT:PSS spectrum reported by Chanthanont and Sirivat, 2013.23 The FTIR spectrum of PEDOT:PSS synthesized in CTAB shows peaks at 2973 and 2898 cm^{-1} , indicating the CH3–N+ anti-symmetric stretching and C–H stretching, respectively, which confirm the incorporation of CTAB in PEDOT:PSS.36 In the case of PEDOT:PSS prepared with SDS , the O–H stretching peak shifts from 3415 to 3339 cm^{-1} because SDS can repel the O–H of PSS by electrorepulsive forces.

For the system of Triton X-100, the FTIR spectrum of PEDOT: PSS is the same as that without surfactant, and it does not show any characteristic peaks of Triton X-100. Thus, Triton X-100 was not incorporated in PEDOT: PSS. For the PEDOT: PSS synthesized at various CTAB concentrations, at the EDOT: PSS weight ratio of 1: 11 and EDOT: $Na_2S_2O_8$ mole ratio of 1: 2, the spectra show the CH3– N+ anti-symmetric stretching of CTAB at 2973 cm^{-1} and the C–H stretching peak at 2898 cm^{-1} ,36 where the intensity of the former increased with an increase in CTAB concentration. In the case of various SDS concentrations, the intensity of the O–H stretching peak of SDS located at 3339 cm^{-1} increased with an increase in SDS concentration. Under various Triton X- 100 concentrations, the FT-IR spectra of PEDOT: PSS were nearly the same with an increase in Triton X-100 concentration.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal



FTIR spectra of PEDOT: PSS at the EDOT: PSS weight ratio of 1:11 and EDOT: $Na_2S_2O_8$ mole ratio of 1:2 with various surfactant

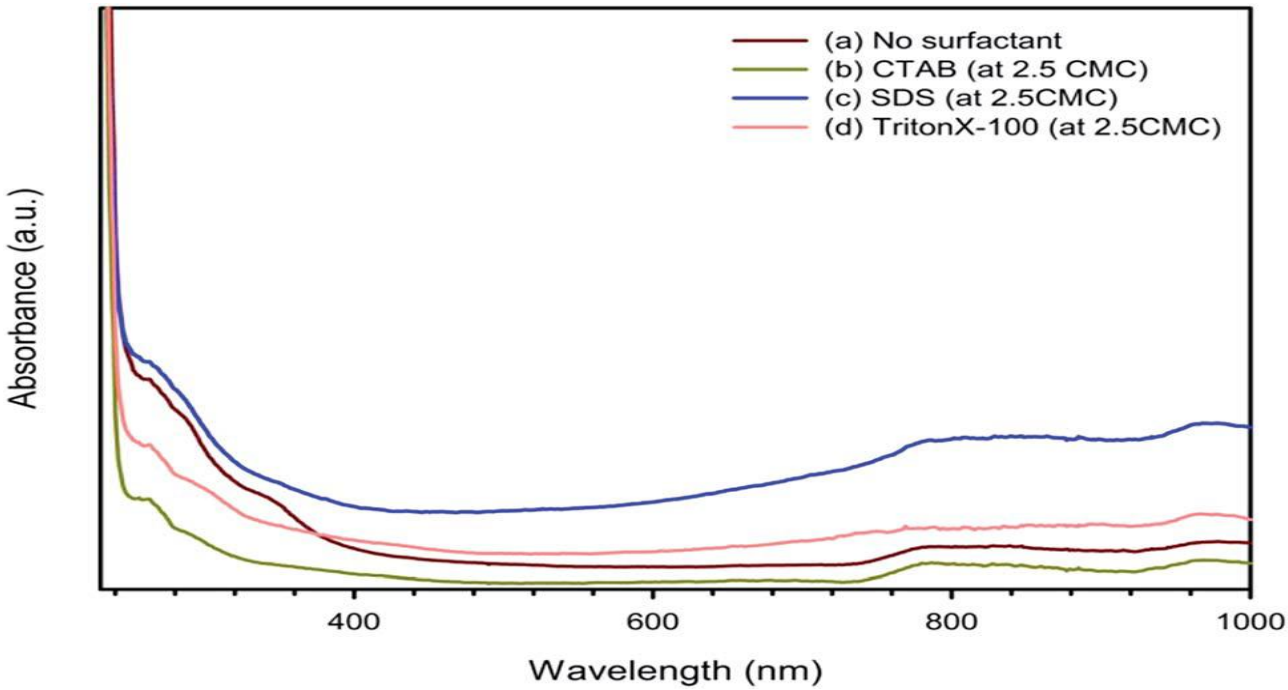
3.1.2 FT Raman analysis

The PEDOT: PSS synthesized at the EDOT: PSS weight ratios of 1: 5, 1: 11, and 1: 13 and EDOT: $Na_2S_2O_8$ mole ratio fixed at 1: 1 were characterized using the FT Raman technique. The FT Raman spectra showed the dominant peak at 1424 cm^{-1}, indicative of the Ca - Cb stretching vibration mode of the quinoid structure in PEDOT. The quinoid structure represents the linear structure or the expanded-coil of the PEDOT: PSS chain, which lies on the same plane. Hence, the conjugated p-electrons can delocalize in the PEDOT chain.40 The PEDOT:PSS synthesized at the EDOT : PSS weight ratio of 1 : 11 and EDOT : $Na_2S_2O_8$ mole ratio of 1 : 2 with Triton-X 100 (2.5CMC) was also characterized via FT-Raman spectroscopy and it was observed that the FT-Raman spectrum with the surfactant was similar to that without surfactant, indicating the same quinoid structure in the PEDOT chain.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

3.2.1 Characteristics of UV spectra.

The UV adsorption spectra of PEDOT: PSS synthesized at the EDOT: PSS weight ratio of 1: 11 and EDOT: Na2S2O8 mole ratio of 1: 2 with surfactants (at 2.5CMC) and without surfactant. All the UV spectra show a UV absorbance at 258 nm, which can be assigned to the substituted phenyl groups in PSS.55 The broad bands between 600 and 900 nm and between 700 to 1000 nm can be ascribed to the polaron and bipolarons states of PEDOT: PSS, respectively, indicative of the characteristic doped state of PEDOT: PSS For the effects of EDOT : PSS weight ratio and EDOT : $Na_2S_2O_8$ mole ratio, the characteristics of the PEDOT:PSS UVspectra were nearly the same with an increase in EDOT : PSS weight ratio or increase in EDOT : $Na_2S_2O_8$ mole ratio, consistent with previous work of Khan and Narula,



UVadsorption spectra of PEDOT: PSS at the EDOT: PSS weight ratio of 1: 11 and EDOT: $Na_2S_2O_8$ mole ratio of 1: 2 using various surfactant types: (a) no surfactant, (b) CTAB (at 2.5CMC), (c) SDS (at 2.5CMC), and (d) Triton X-100 (at 2.5CMC).

3.2.2 Band gap energy.

The band gap energy of PEDOT: PSS was calculated by using the Tau relation. In the case of various EDOT: PSS weight ratios, the band gap energy of PEDOT: PSS prepared at the EDOT: PSS weight ratio of 1: 5 (2.92 eV) WAS higher than that for the EDOT: PSS weight ratio of 1: 11 (2.67 eV). This indicates that at a higher PSS content, a larger number of SO3 groups from PSS is available to interact with PEDOT However, at the EDOT : PSS weight ratio of 1 : 13, the band gap energy is higher at 2.72 eV due to the over- .51 For the effect of EDOT : $Na_2S_2O_8$ mole ratio, at the EDOT : PSS weight ratio of 1 : 11, the band gap energy of the EDOT : $Na_2S_2O_8$

mole ratio of 1 : 2 possessed the lowest value of 1.90 eV. This is due to the $SO4_2$_ ions from the oxidant interacting with the PEDOT chains as a dopant. This result is consistent with the increments in % PSS^- and % SO_4^{2-} determined by XPS. The doping process generally reduces the band gap energy between the HOMO and the LUMO to a level between 1–4 eV, as reported by Kar et al., 2013.2 However, the band gap energy for the EDOT : $Na_2S_2O_8$ mole ratio of 1 : 4 is larger because a large number of Na+ ions from the oxidant can interact with the PSS_ chains to form PSSNa, which reduces the amount of doping sites on PSS. This result is consistent with the XPS result, indicating an increase in PSSNa, and the XRD result showing the highly crystalline peaks of PSSNa. For the effect of surfactant type on the band gap energy of PEDOT:PSS, at the EDOT : PSS weight ratio of 1 : 11 and EDOT : $Na_2S_2O_8$ mole ratio of 1 : 2 utilizing Triton X-100 at 2.5CMC, this condition provided a band gap energy of 1.80 eV, which is lower than that of 3.00 eV for 2.5CMC SDS and 3.5 eV for 2.5CMC CTAB. Triton X-100 at 2.5CMC increases the HOMO level, allowing the polarons and bipolarons to delocalize.2 CTAB and SDS provide higher band gap energies since they can obstruct the interaction of PSS with PEDOT, resulting in higher energy barriers between the HOMO and LUMO levels. For the effect of Triton X-100 concentrations, a higher concentration provides a higher band gap energy above 2.5 CMC, where too many Triton X-100 molecules can obstruct the PEDOT and PSS interaction and form the TX-PSS complex, but can be removed by methanol washing. The optimum Triton-X 100 concentration is 2.5CMC due to its lowest band gap energy (1.80 eV).

4. Conclusion:

PEDOT: PSS was successfully synthesized via chemical oxidative polymerization with high electrical conductivity and a systematic route was used to investigate the effects of EDOT: PSS weight ratio, EDOT: $Na_2S_2O_8$ mole ratio, and surfactant type and concentration on its properties. The EDOT: PSS weight ratio of 1: 11 provided the highest PSS dopant amount to interact with PEDOT. For the effect of EDOT: $Na_2S_2O_8$ mole ratio, the EDOT: $Na_2S_2O_8$ mole ratio of 1: 2 was the optimal condition since SO4 2^- from the oxidant acting as a secondary dopant increased the number of charge carriers, resulting in the high electrical conductivity of 1556.85- 46.84 S cm^{-1} and low energy gap of 1.90 eV. In the case of the three surfactant systems, Triton X-100 (2.5CMC) was the suitable surfactant to synthesize PEDOT: PSS, at the EDOT: PSS weight ratio of 1: 11 and EDOT: $Na_2S_2O_8$ mole ratio of 1: 2 because of the highest electrical conductivity of 1879.49 cm^{-1} 13.87 S cm^{-1} and the lowest energy gap of 1.80 eV. Triton X-100 molecules reduced the PEDOT and PSS interactions and the amount of PSSNa, which could be easily removed by methanol washing. The washing reduced the PSSNa amount on PSS, which then provided a higher number of doping sites on PSS. The particle shape of the PEDOT: PSS synthesized in all conditions were spherical. The particle size of PEDOT: PSS varied from 16.57 - 1.99 to 56.77 - 5.54 nm. The thermogravimetric analysis revealed that PEDOT: PSS with surfactants exhibited lower thermal stability than PEDOT: PSS without surfactant. The synthesis of PEDOT: PSS in this work provides guidance for the production and use of PEDOT: PSS particles in powder form with very high electrical conductivity, potentially suitable for many electronic applications such as drug delivery, thin film transistors, light emitting diodes, sensors, photovoltaics, and actuators.

References:

1 T. H. Le, Y. Kim and H. Yoon, Polymers, 2017, 9, 150.

2 P. Kar, Doping in conjugated polymers, Scrivener Publishing LLC, Canada, 1st edn, 2013.

3 H. Shirakawa, E. J. Louis, A. G. MacDiarmid, C. K. Chiang and A. J. Heeger, J. Chem. Soc., Chem. Commun., 1997, 578– 580.

4 N. Hall, Chem. Commun., 2003, 1–4.

5 W. S. Huang, B. D. Humphrey and A. G. MacDiarmid, J. Chem. Soc., Faraday Trans. 1, 1986, 82, 2385–2400.

6 R. D. McCullough, R. D. Lowe, M. Jayaraman and D. L. Anderson, J. Org. Chem., 1993, 58, 904–912.

7 L. Dai, B. Winkler, L. Dong, L. Tong and W. H. A. Mau, Adv. Mater., 2001, 13, 915–925.

8 H. E. Katz, J. Mater. Chem., 1997, 7, 369–376.

9 M. Hiraoka, P. Fiorini, J. O'Callaghan, I. Yamashita, C. V. Hoof and M. Op de Beeck, Sens. Actuators, A, 2012, 177, 23–29.

10 K. Yan, Z.-X. Liu, X. Li, J. Chen, H. Chen and C.-Z. Li, Org. Chem. Front., 2018, 5, 2845.

11 D. Svirskis, J. Travas-Sejdic, A. Rodgers and S. Garg, J. Controlled Release, 2010, 146, 6–15.

12 N. Paradee and A. Sirivat, Polym. Int., 2013, 63, 106–113.

13 L. Ouyang, C. Musumeci, M. J. Jafari, T. Ederth and O. Ingan¨as, ACS Appl. Mater. Interfaces, 2015, 7, 19764–19773.

14 A. Cho, S. Kim, S. Kim, W. Cho, C. Park, F. S. Kim and J. H. Kim, J. Polym. Sci., Part B: Polym. Phys., 2016, 54, 1530–1536.

15 K. Muro, M. Watanabe, T. Tamai, K. Yazawa and K. Matsukawa, RSC Adv., 2016, 6, 87147–87152.

16 C. Liu, F. Jiang, M. Huang, R. Yue, B. Lu, J. Xu and G. Liu, J. Electron. Mater., 2011, 40, 648–651.

17 S. Lim, S. H. Park, T. K. An, H. S. Lee and S. H. Kim, RSC Adv., 2015, 6, 2004–2010.

18 J. Ouyang, Q. Xu, C.-W. Chu, Y. Yang, G. Li and J. Shinar, Polymer, 2004, 45, 8443–8450.

19 J. Y. Oh, M. Shin, J. B. Lee, J. H. Ahn, H. K. Baik and U. Jeong, ACS Appl. Mater. Interfaces, 2014, 6, 6954–6961.

20 T. Horii, H. Hikawa, Y. Mochizuki and H. Okuzaki, Trans. Mater. Res. Soc. Jpn., 2012, 37, 515–518.

21 M. C. Lefebvre, Z. Qi and P. G. Pick up, J. Electrochem. Soc., 1999, 146, 2054–2058.

22 W. Wichiansee and A. Sirivat, Materials Science and Engineering C., 2008, 29, 78–84.

23 P. Chanthanont and A. Sirivat, Polym. Adv. Technol., 2013, 32, 21367.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

CHANGING POLITICAL SCENARIO OF TRIBAL COMMUNITIES IN AHMEDNAGAR

Prof. Telore Babasaheb Haridas
Adv.M.N.Deshmukh Arts, Science and Commerce college, Rajur
Ta-Akole Dist-A.Nagar
bhushantelore11@gmail.com
Contact: 9130393366
Affiliated to Savitribai Phule Pune University

Abstract:

The political life of tribal communities in Ahmednagar district of Maharashtra has undergone significant transformation over the past few decades. Traditionally, tribal groups such as Mahadev Koli, Bhil, Thakar, Gond, Pardhi, and Katkari lived in remote and hilly regions, largely isolated from mainstream political processes. Their participation in politics was minimal due to factors such as illiteracy, poverty, lack of awareness, and geographical inaccessibility. However, with the passage of time, various socio-economic and political developments have brought notable changes in their political life. One of the most important changes is the increase in political awareness among tribal communities. The expansion of education, along with government initiatives such as tribal hostels, scholarships, and literacy programs, has empowered tribal youth with knowledge about their constitutional rights and duties. As a result, they have become more conscious of democratic processes such as voting, elections, and governance. The role of mass media, including television, mobile technology, and social media, has further contributed to spreading political information and awareness in even the most remote tribal areas. Another major transformation is the growing participation of tribal people in electoral politics. Earlier, tribal voters were often influenced by local elites or traditional leaders. Today, they are increasingly making independent political choices and actively participating in elections at local, state, and national levels.

Key words: *Political development, Minimal awareness, Elites, Communities*

Introduction:

Ahmednagar district in Maharashtra is known for its diverse tribal population, including communities such as Mahadev Koli, Bhil, Thakar, Gond, Pardhi, and Katkari. These tribal groups are mainly concentrated in the hilly and forest regions of Akole and surrounding areas. Historically, they have lived in relative isolation from the mainstream society, maintaining their own cultural traditions, social structures, and ways of life. Due to factors such as illiteracy, poverty, and geographical remoteness, their participation in political processes remained limited for a long period. In the past, tribal communities had minimal awareness about democratic institutions, elections, and their constitutional rights. Political decisions were often influenced by local leaders, landlords, or dominant social groups. As a result, tribal people were largely excluded from active political participation and representation. However, after

independence, the Government of India introduced several measures to integrate tribal communities into the national mainstream. These included constitutional safeguards, reservation policies, and targeted welfare schemes aimed at their socio-economic and political development. Over time, significant changes have taken place in the political life of tribal communities in Ahmednagar district. The spread of education, increased access to information, development programs, and the functioning of Panchayati Raj institutions have contributed to greater political awareness and participation. Tribal individuals are now actively involved in elections and local governance. This study aims to examine the nature of these changes and understand how they have influenced the political empowerment of tribal communities in the district.

Increase in Political Awareness:

The increase in political awareness among tribal communities in Ahmednagar district is one of the most significant changes observed in recent years. Traditionally, tribal groups such as Mahadev Koli, Bhil, Thakar, and Katkari lived in remote and forested areas, largely disconnected from mainstream political processes. Due to illiteracy, poverty, and geographical isolation, they had limited knowledge about their political rights, government schemes, and the importance of participation in democratic institutions. However, this situation has gradually changed due to several influencing factors. One of the major reasons for this transformation is the spread of education. Government initiatives to promote education among tribal populations have led to an increase in literacy rates. Schools, hostels, and scholarship schemes have enabled tribal youth to access formal education.

As a result, educated individuals within these communities have begun to understand the importance of voting, representation, and participation in governance. Education has also helped them question traditional authority structures and make independent political choices. Another important factor is the role of mass media and communication. The expansion of television, mobile phones, and the internet has brought political information closer to tribal areas. News channels, social media platforms, and government awareness campaigns have helped tribal people stay informed about elections, political parties, and their rights as citizens. This exposure has reduced their dependence on middlemen or local leaders for political information and has encouraged independent thinking.

Government policies and welfare schemes have also played a crucial role in increasing political awareness. Programs aimed at tribal development, such as reservations in education, employment, and political institutions, have created opportunities for participation and empowerment.

Tribal communities directly benefit from such schemes they become more interested in political processes and governance. Awareness campaigns conducted by government agencies and non-governmental organizations (NGOs) have further educated them about their rights and responsibilities. In addition, the role of local self-government institutions has been significant. The implementation of the Panchayati Raj system has brought governance closer to the grassroots level. Tribal individuals now participate in Gram Sabha meetings, where they can

voice their concerns and contribute to decision-making processes. This direct involvement has increased their confidence and understanding of political systems.

Social movements and community-based organizations have also contributed to this change. Various tribal organizations have worked to raise awareness about issues such as land rights, forest rights, and social justice. These movements have encouraged tribal people to organize collectively and demand their rights from the government. As a result, political consciousness has grown stronger within these communities.

Growing Participation in Elections:

The participation of tribal communities in elections in Ahmednagar district has increased significantly in recent years. Earlier, tribal people showed limited interest in voting due to lack of awareness, illiteracy, and influence of traditional leaders or dominant groups. Many were unaware of the importance of elections and their role in a democratic system. As a result, their voter turnout was comparatively low, and their political voice remained weak. However, with the spread of education and awareness programs, tribal communities have become more conscious of their voting rights. Government initiatives, election campaigns, and efforts by social organizations have encouraged them to actively participate in the electoral process. Today, both men and women from tribal areas are coming forward to vote in large numbers during local, state, and national elections.

Another important change is that tribal voters are now making independent decisions rather than being influenced by local elites. They evaluate candidates and political parties based on development issues such as roads, water supply, education, and employment opportunities. This shift reflects a growing sense of political maturity and responsibility. Increased participation in elections has strengthened the political representation of tribal communities and has given them a stronger voice in the democratic system.

Impact of Government Policies and Reservations:

Government policies and reservation provisions have played a vital role in transforming the political life of tribal communities in Ahmednagar district. After independence, the Constitution of India provided special safeguards for Scheduled Tribes to ensure their social, economic, and political development. One of the most important measures is the system of reservation in education, government jobs, and political institutions, which has created opportunities for tribal empowerment.

In the political sphere, reservation of seats for Scheduled Tribes in local self-government bodies such as Gram Panchayats, Panchayat Samitis, and Zilla Parishads has increased their representation. This has enabled tribal individuals to participate directly in decision-making processes and address issues related to their communities. As a result, many tribal leaders have emerged at the grassroots level. Various government welfare schemes focusing on education, healthcare, employment, and infrastructure have also contributed to raising political awareness. Programs like tribal hostels, scholarships, and skill development initiatives have improved their socio-economic conditions, encouraging them to engage more actively in politics.

Role of Political Parties:

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Political parties have played an important role in shaping the political life of tribal communities in Ahmednagar district. In earlier times, tribal areas received limited attention from major political parties, and their issues were often neglected. However, with the growing importance of elections and increasing voter awareness, political parties have started recognizing tribal communities as a significant part of the electorate. Today, political parties actively reach out to tribal voters during election campaigns. They organize rallies, meetings, and awareness programs in tribal regions to gain support. Leaders visit remote villages, listen to local problems, and promise development initiatives such as better roads, water supply, education, and employment opportunities. This has helped in bringing tribal issues into the political mainstream. Political parties also play a role in selecting tribal candidates, especially in constituencies reserved for Scheduled Tribes. This has created opportunities for tribal representation in local and regional politics. As a result, tribal leaders are now emerging within party structures and participating in decision-making processes.

Continuing Challenges:

Despite progress in political awareness and participation, many tribal areas in Ahmednagar district still face a serious lack of basic facilities. Essential services such as clean drinking water, proper healthcare, education, roads, and electricity are inadequate in remote and hilly regions. This underdevelopment affects the overall quality of life and limits access to information and political processes. Due to poor infrastructure, tribal people often struggle to attend meetings, participate in governance, or benefit from government schemes. As a result, their political empowerment remains incomplete. Improving basic facilities is essential for ensuring equal participation and inclusive development of tribal communities. Limited awareness in remote tribal regions remains a major challenge in Ahmednagar district. Many villages located in hilly and forest areas still have restricted access to education, communication, and information sources. Due to this, people are not fully aware of their political rights, government schemes, and democratic processes. Illiteracy and lack of exposure further increase their dependence on local leaders or middlemen for decision-making. This situation affects independent political participation and informed voting. Although awareness is improving gradually, special efforts such as education programs, awareness campaigns, and better connectivity are needed to bridge this gap and ensure inclusive political development.

Dependence on local leaders is still a significant challenge among tribal communities in Ahmednagar district. In many areas, people rely heavily on village heads, influential individuals, or traditional leaders for political guidance and decision-making. Due to limited education and awareness, voters often follow the instructions of these leaders rather than making independent choices. This can sometimes lead to biased decisions and manipulation during elections. Such dependence weakens true democratic participation and limits the development of independent political thinking. Therefore, increasing education, awareness, and access to information is essential to reduce this dependence and promote informed and independent participation.

Poverty and marginalization continue to be major obstacles for tribal communities in Ahmednagar district. Many tribal families live below the poverty line and lack access to stable income, proper education, and healthcare facilities. This economic hardship limits their ability to actively participate in political activities and decision-making processes. Marginalization from mainstream society further reduces their opportunities for representation and development. Due to these conditions, their voices are often unheard in governance. Although government schemes aim to uplift them, the benefits do not always reach all sections. Addressing poverty and social exclusion is essential for achieving true political empowerment.

Conclusion:

The political life of tribal communities in Ahmednagar district has witnessed significant and positive changes over the years. From a stage of isolation and limited participation, these communities are gradually becoming active participants in the democratic process. The increase in political awareness, growing participation in elections, emergence of tribal leadership, and the impact of government policies and reservations have all contributed to this transformation.

Education has played a key role in empowering tribal people by making them aware of their rights and responsibilities. Along with this, the expansion of communication and media has helped in spreading political knowledge even in remote areas. As a result, tribal communities are no longer passive voters but are increasingly making independent and informed political decisions. Their participation in local self-government institutions such as Gram Panchayats, Panchayat Samitis, and Zilla Parishads has strengthened their representation and voice in governance.

Government initiatives, including reservation policies and welfare schemes, have created opportunities for political inclusion and socio-economic development. Political parties have also recognized the importance of tribal voters, which has further increased their involvement in the political system. However, despite these positive developments, several challenges still remain. Issues such as poverty, lack of basic facilities, limited awareness in remote areas, and dependence on local leaders continue to hinder full political empowerment.

In conclusion, while the progress made by tribal communities in Ahmednagar district is encouraging, there is still a need for sustained efforts. Improving education, infrastructure, and access to information, along with effective implementation of government policies, is essential. Only through inclusive development and continuous support can tribal communities achieve complete political empowerment and actively contribute to the democratic system.

Reference:

1. Kakade, Lahu Baban. *"The Changes Taking Place in the Social Life of the Tribal Communities in Ahmednagar District."* International Journal of Science and Research, Vol. 14, Issue 6, 2024, pp. 1–5.
2. Pawar, Rajendra Sitaram. *"A Geographical Study of Concentration of Tribal Population and Their Literacy in Akole Tahsil, District Ahmednagar."* International Journal of Science and Research, Vol. 4, Issue 4, 2015, pp. 2924–2928.

3. Rajole, Basawaraj. *"Socio-Political Awareness Among Tribal People of India – A Study."* Indian Streams Research Journal, Vol. 13, Issue 7, 2023, pp. 1–6.
4. Kumar, K. Anil & Reddy, M. Gopinath. *"Political Economy of Tribal Development: A Case Study."* IOSR Journal of Humanities and Social Science, pp. 50–59.
5. Government of India *"Report of the Scheduled Tribes Commission."* New Delhi, pp. 10–25.
6. Ministry of Tribal Affairs, Government of India. *"Annual Report on Tribal Development."* New Delhi, Latest Edition, pp. 15–40.

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
E-ISSN: 3049-3846
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

GROWTH OF START-UP ECOSYSTEM IN INDIA: OPPORTUNITIES AND CHALLENGES

Sindhu M.R
Assistant Professor, Department of Economics,
Patkar- Varde College, Goregaon, Mumbai
EMAIL: sindhuravi21@gmail.com
Contact Number :7021227329

ABSTRACT

A startup is a brand-new company that prioritizes innovation, market expansion, and quick growth. India has recently become one of the world's fastest-growing startup ecosystems. Startups are crucial for fostering innovation, creating jobs, and boosting the economy. The startup ecosystem has benefited from the digital economy's explosive growth. Startups in industries including e-commerce, fintech, education technology, and health technology now have more prospects because to the widespread usage of smartphones, reasonably priced internet access, and digital platforms. The growing availability of venture capital and private financing is another significant factor contributing to the expansion of startups. Successful Indian startups that have developed into international names include Flipkart, Paytm, Ola Cabs, and Zomato. The number of unicorn firms worth more than $1 billion has also significantly increased in India. Several Indian cities have become important centres for startups. Bengaluru, Mumbai, Delhi, Hyderabad, and Chennai are important startup hubs. Notwithstanding these successes, the Indian startup ecosystem continues to confront obstacles like difficult access to capital for early-stage companies, regulatory barriers, and fierce rivalry in the market. The ecosystem may be strengthened even further by addressing these issues with better infrastructure and policy changes.

KEY WORDS: Start-up hubs, innovation & technology, employment, Startup India initiative, Ecosystem Growth

INTRODUCTION

Arun Jaitley launched Startup India on January 16, 2016, under the leadership of Narendra Modi. This initiative aims to provide financial and policy support to startups so they can transform innovative ideas into successful businesses. Managed by the Department for Promotion of Industry and Internal Trade, it has become a key pillar of India's entrepreneurial ecosystem. Over the years, the program has evolved into a comprehensive platform supporting startups from idea generation to expansion. India's startup ecosystem has grown significantly, with unicorns increasing from 4 in 2014 to over 120 today, reflecting strong global relevance. Startups are generating employment across sectors and creating indirect opportunities through supply chains and gig work. They also collaborate with large firms and multinational

companies for growth and technology transfer. Overall, Startup India empowers aspiring entrepreneurs, helping them overcome financial barriers and contribute to a stronger economy.

RESEARCH OBJECTIVES:

1. To examine the growth of Start-Up Ecosystem in India
2. To identify the opportunities available for Start -Ups in India.
3. To study the Government initiatives in promoting Start-Ups in India.
4. To analyse the challenges faced by Start-Ups in India.

RESEARCH METHODOLOGY

This research study is purely based on secondary data. Secondary data sources comprise of data collected from journals, magazines, news articles, authenticated websites, newsletter, and annual reports from Ministry of commerce & industry, Department for Promotion of industry and Internal Trade (DPIIT) and from other sources found suitable. The study is descriptive and conceptual in nature.

LITERATURE REVIEW

(Baporikar, 2014) in her research paper "youth entrepreneurship in Indian scenario" discusses about the role of youth entrepreneurship with a focus on Indian scenario by integrating it to several other factors such as business models for YE, barriers affecting YE and its impact on reducing unemployment.

(Kshetri & Kshetri, 2016) in their research article "Fostering startup ecosystem in India" have mentioned out the factors and consequences responsible for fostering the growth of startup ecosystem in India.

(Andaleeb & Singh, 2016) in their research report titled as "A study of Financing Sources for Start-up Companies in India" have described the stages of startups and modes of financing available to startups at each stage.

(Adhana, 2016) in his research paper "Start-Up India, Stand-Up India: India Turning into a Start-Up Hub by Prospering Entrepreneurial Culture" clearly explains the startup ecosystem in Indian scenario. The entrepreneurial culture, the funding sources, types of investors and reasons of success and failures of startups have also been stated.

(Manshani & Dubey, 2017) have conducted the research study on Women entrepreneurs in India and have concluded several factors that promotes & encourages women empowerment in entrepreneurial development.

(Jha, 2018) in her research article "Entrepreneurial ecosystem in India- Taking stock and looking ahead" had stated the role of education & training and other socio-cultural issues responsible for building the startup ecosystem in India.

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

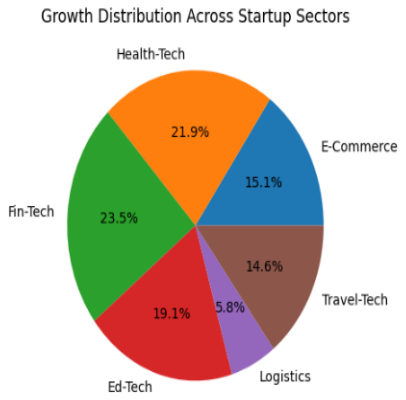
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

The Growth of Start-Up Ecosystem in India

Unquestionably, both India and the Indian startup scene are expanding. The Indian government has designated the years 2010–2020 as the "decade of innovation." Many fresh and inspiring startup stories have received much-needed attention in recent years. We encounter these businesses daily for our daily needs, whether they are payment services like Paytm and PhonePe, educational technologies like Unacademy and Physics Wallah, or food tech startups like Zomato and Swiggy. The tale of the Indian startup ecosystem is everywhere.

Sector	Growth / Potential	Popular Startups
E-Commerce	CAGR of 27%	Flipkart, Nykaa, Snapdeal
Health-Tech	39% growth rate	PharmEasy, CureFit, MFine
Fin-Tech	$106 billion, ~42%	Paytm, PolicyBazaar, PhonePe
Ed-Tech	$30 billion, ~34%	Unacademy, Physics Wallah, Vedantu
Logistics	10.4% growth	Delhivery, Blinkit, Ekart
Travel-Tech	$30 billion, ~26%	Goibibo, MakeMyTrip, Yatra, OYO

Key Sectors in the Start-Up Eco System:



The table highlights key high-growth sectors in the startup ecosystem. Health-tech and fintech show the fastest growth rates, indicating strong demand for digital financial and healthcare services. E-commerce and ed-tech are also expanding rapidly due to increased internet usage and online learning trends. Logistics and travel-tech show steady growth, supporting the rise of online businesses and tourism.

Number of start-ups recognised by DPIIT

Year	No. of Start Ups
2018	8635
2019	11279
2020	14498
2021	200046
2022	26542
2023	17119

Source: Press Information Bureau, GOI

The table shows the growth trend in the number of startups over the period from

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

2018 to 2023. Overall, it indicates a rising interest in entrepreneurship, although there are some fluctuations in later years. From 2018 to 2020, the number of startups increased steadily. In 2018, there were 8,635 startups, which grew to 11,279 in 2019 and further to 14,498 in 2020. This consistent rise reflects a supportive business environment, increasing digitalization, and government initiatives promoting startups.

Officially recognised start-ups in India

Year	No. of Start Ups
2016	471
2017	5704
2018	14339
2019	25618
2020	40116
2021	60162
2022	86704
2023	112718
2024	127433

Source: Statista, DPIIT

The table shows a steady and rapid growth in the number of startups from 2016 to 2024. Starting from just 471 startups in 2016, the number increased significantly each year, reaching 127,433 in 2024.This consistent rise indicates a strong expansion of the startup ecosystem, supported by factors like government initiatives, increased funding, and digital growth. Overall, the trend reflects a thriving entrepreneurial environment with positive prospects.

State/ UT Wise Contribution to Start up Eco System in India

State/ UT	Contribution to Start Up Eco System
Maharashtra	37.4%
Delhi NCR	20.2%
Karnataka	12.4%
Kerala	9.6%
Telangana	9.1%
Tamil Nadu	8.4%

Source: DPIIT

The table shows the contribution of different states and union territories to the startup ecosystem. Maharashtra has the highest share at 37.4%, making it the leading startup hub. Delhi

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

NCR follows with 20.2%, while Karnataka contributes 12.4%. Other states like Kerala (9.6%), Telangana (9.1%), and Tamil Nadu (8.4%) also play significant roles. Overall, the data shows that the startup ecosystem is concentrated in a few major regions.

Opportunities Available for Start -Ups in India

1. India's large population is a major advantage, with a growing working-age group creating strong opportunities for startups. This demographic benefit, along with untapped markets and infrastructure needs, offers significant scope for business growth and innovation.
2. India's telecom sector, with nearly 100 crore subscribers, has expanded connectivity across rural and urban areas. Government digital initiatives and affordable data have made internet access widespread, enabling startups to reach new markets, penetrate traditional sectors, and drive innovation.
3. Changing mindsets among the working class are boosting India's startup ecosystem. Professionals and students are increasingly choosing startups over traditional careers due to better opportunities, pay, and innovation, with many executives also shifting to startup roles.
4. India's large youth population drives innovation, talent, and entrepreneurship. Challenges in areas like education, health, and infrastructure create strong opportunities for startups. With a growing middle class and diverse population, India offers vast potential for developing a wide range of products and services.

Government Initiatives in Promoting Start-Ups in India.

1. STARTUP INDIA ACTION PLAN: A flagship Government of India initiative to build a strong startup ecosystem, promote innovation, generate employment, and support startup growth while accelerating the startup movement.
2. STARTUP INDIA SEED FUND SCHEME: SISFS created by DPIIT (Department for Promotion of Industry and Internal Trade of India) with an outlay of Rs. 945 crores to provide financial assistance to Startups. This scheme aims to build a robust Startup ecosystem in the country for innovation and provides opportunities to the new entrepreneurs.
3. ATAL INNOVATION MISSSION (AIM): A platform promoting innovation through hubs, grand challenges, and talent initiatives. It supports Atal Tinkering Labs (14,916 selected), innovation, and incubation centres, and 86 incubators across India with financial assistance through grants.
4. SAMRIDH SCHEME [STARTUP ACCELERATOR OF MEITY FOR PRODUCT IN NOVATION, DEVELOPMENT AND GROWTH]: The SAMRIDH scheme, launched by the Ministry of Electronics and Information Technology, supports startups by helping them enter and scale in Indian and global markets. It provides funding up to ₹40 lakhs, connects startups with incubators, mentors, and investors, and offers technical, financial, regulatory, and market access support.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

5. eBiz PORTAL first online forum for government-to-business collaboration (G2B), which has been launched by Ministry of Commerce and Industry, developed by Infosys, is a public-private partnership model to provide a one-stop shop for investors and business communities in India.
6. STARTUP INDIA HUB: The Government launched a Startup India Online Hub on 19th June 2017 which is one of its kind online plat forms for all stakeholders of the entrepreneurial ecosystem in India to discover, connect and engage with each other.
7. THE STARTUP INDIA INVESTOR CONNECT PORTAL: It is co-developed under the Startup India Initiative with SIDBI, this platform connects startups with investors to help them raise funds. It mainly supports early-stage startups across India by enabling them to showcase their ideas to venture capital funds. Currently, over 82 AIFs and 1,900 startups are registered on the platform.

8. FUND OF FUNDS FOR START UPS (FFS): FFS is a flagship initiative of the DPIIT under the Startup India Action Plan and is managed by the Small Industries Development Bank of India (SIDBI) which supports SEBI-registered Alternative Investment Funds (AIFs), which in turn invest in startups, with the objective of expanding access to domestic risk capital and strengthening the entrepreneurial ecosystem.
9. CREDIT GUARENTEE SCHEME FOR START UPS: It is implemented for enabling collateral free loans to startups through eligible financial institutions. CGSS is operationalized by the National Credit Guarantee Trustee Company (NCGTC) Limited. Under CGSS, 330+ loans worth over ₹800 crore have been guaranteed for startup borrowers.
10. NATIONAL MENTORSHIP PORTAL(MAARG):_This program has been developed to provide startups across the country with easy access to mentorship. The portal aims to support startup growth, offer strategic guidance, and strengthen the overall entrepreneurial ecosystem nationwide.
11. GENESIS (GEN-NEXT SUPPORT FOR INNOVATION START UPS): The GENESIS initiative, a National Deep-tech Startup Platform by Ministry of Electronics and Information Technology (MeitY), was launched in July 2022, which aims to scale up about 1600 technology startups through implementing agencies across India, provides significant funding and support for deep-tech innovation. MeitY Start Up Hub (MSH) drives technology-led economic growth and innovation and acts as a central platform connecting incubation centres, Centres of Excellence on Emerging Technologies, and other platforms supported by the MeitY.
12. TECHNOLOGY INCUBATION AND DEVELOPMENT OF ENTREPRENEURS (TIDE) 2.0 SCHEME: This scheme launched in 2019 by the Ministry of Electronics and Information Technology; the TIDE 2.0 scheme promotes technology-based startups by strengthening incubators. It supports ICT startups in areas like AI, IoT, blockchain, and

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

robotics across sectors such as healthcare, education, agriculture, and clean tech, through 51 incubators in leading institutions across India.

13. NIDHI (NATIONAL INITIATIVE FOR DEVELOPING AND HARNESSING INNOVATIONS): It is an umbrella programme launched in 2016 by the Department of Science and Technology (DST), Ministry of Science and Technology, which acts as nurturing ideas and innovations into successful startups. The programme aims to build an innovation-driven ecosystem that promotes entrepreneurship, leading to socio-economic development, wealth creation, and employment generation.
14. STARTUP VILLAGE ENTREPRENEURSHIP PROGRAM (SVEP): Launched in 2015 under DAY-NRLM, the Startup Village Entrepreneurship Programme (SVEP) promotes rural entrepreneurship by supporting self-employment and skilled jobs, helping reduce poverty and create sustainable livelihoods.
15. A SCHEME FOR PROMOTION OF INNOVATION, RURAL INDUSTRIES AND ENTREPRENEURSHIP (ASPIRE): Launched by the Ministry of MSME in 2015, the scheme promotes innovation and entrepreneurship in rural and underserved areas by setting up Livelihood Business Incubators, creating micro-enterprises, and providing skill development and employment opportunities.
16. PRIME MINISTER'S EMPLOYMENT GENERATION PROGRAMME (PMEGP): Launched in 2008 under the Ministry of MSME, the Prime Minister's Employment Generation Programme (PMEGP) promotes self-employment and grassroots enterprises. It merged PMRY and REGP and is implemented by KVIC to ensure wide outreach and effective delivery.

Challenges Faced by Start-Ups in India.

1. Funding Crunch: Layoffs and operational reductions have resulted from a tightening of venture capital inflows due to the global economic slump and rising interest rates.
2. Regulatory and Compliance Issues: Despite government assistance, businesses must deal with complicated tax structures, compliance obligations, and regulatory uncertainties, such as ESOP taxation regulations and recent data protection laws.
3. Scaling Challenges: Many firms' attempts to scale are hampered by operational inefficiencies, a lack of market adaptation, and inadequate infrastructure.
4. High Failure Rate: Due to issues like poor product-market fit, insufficient financial planning, and an inability to adjust to customer expectations, more than 90% of Indian companies fail within five years.
5. Talent Acquisition and Retention: Retention efforts are complicated by economic uncertainty and competition for talented talent, especially in AI, machine learning, and cybersecurity.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

6. Lack of Access to Quality Healthcare in Rural Areas: Rural India faces limited access to quality healthcare due to poor infrastructure and shortage of medical staff. Biotech solutions like telemedicine, mobile diagnostics, and AI-based care can improve accessibility, affordability, and healthcare delivery in these areas.
7. Unemployment and Underemployment Among Youth: India faces rising youth unemployment due to skill mismatches, especially in urban areas. Startups focusing on skill-based training, micro-internships, and job-matching platforms can improve employability, while promoting opportunities for women can further boost employment.
8. Gaps in the Education System and Digital Learning: Rural education in India faces challenges like outdated curricula, teacher shortages, and skill gaps. EdTech companies can bridge this gap through peer learning, localized content, and skill-based training aligned with industry needs.
9. Agricultural Challenges Faced by Indian Farmers.: Small farmers face low prices, climate risks, and poor market access. Agri-tech startups can improve incomes through solutions like precision farming, better market linkages, fair pricing, and access to finance.
10. Financial Inclusion and Access to Banking Services: Despite the Jan Dhan Yojana's low adoption, rural and marginalized groups frequently lack access to banking and credit. In India, the gap can be filled by microloan platforms, digital wallets, credit scoring using smartphone data, and fintech-based SME finance, which would spur growth and entrepreneurship at the local level.
11. Traffic Congestion and Urban Mobility Issues: Urban India faces congestion, pollution, and traffic delays. Startups can address these issues through last-mile mobility, smart parking, improved ride-hailing, and AI-based public transport solutions.
12. Water Scarcity and Clean Drinking Water Solutions: Water scarcity in India is driven by urbanization, poor infrastructure, and groundwater issues. Startups can tackle this through solar purification, smart leakage detection, and water recycling solutions.

CONCLUSION

India’s startup ecosystem is at a turning point, shifting from rapid expansion to sustainable growth as it marks ten years of the Startup India Initiative. The ecosystem now reflects structural transformation driven by digital infrastructure, demographic advantages, and ongoing reforms. Startups are deeply integrated into key sectors, promoting innovation, job creation, and global market participation. As India moves toward a $7.3 trillion economy by 2030 and the vision of Viksit Bharat 2047, startups will remain key growth drivers. They are also bridging the rural-urban divide through solutions in Agri-tech, telemedicine, microfinance, tourism, and ed-tech, improving livelihoods. Women-led startups are emerging as a strong

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

force for inclusive growth, with over 45% having at least one female leader. This highlights innovation as both an economic and social development engine.

REFERENCES

1. https://www.forbes.com/advisor/investing/what-is-a-startup
2. https://economictimes.indiatimes.com/small-biz/startups/indian-startups-challengesandopportunities.
3. www.managementstudyguide.com
4. https://blog.mygov.in/youth-entrepreneurship-an-emerging-trend-in-india/
5. https://startuptalky.com/startup-failure-success-rates-statistics/
6. https://blog.mygov.in/editorial/startup-india-what-it-means-for-the-youth/
7. Kshetri, N., & Kshetri, N. (2016). Fostering startup ecosystems in India. Asian Research Policy, 7(1), 94-103.
8. Baporikar, N. (2014). Youth entrepreneurship in Indian scenario. International Journal of Asian Business and Information Management (IJABIM), 5(2), 74-84.
9. Andaleeb, U., & Singh, S. D. (2016). A study of Financing Sources for Start-up Companies in India. International Review of Business and Finance, 8(1)
10. Manshani, S., & Dubey, A. (2017). Startup women in startup India: A study of women entrepreneurs in India. International Journal of Business Management (IJBGM), 6(4), 91- 100.
11. Jha, S. K. (2018). Entrepreneurial ecosystem in India: Taking stock and looking ahead. IIMB management review, 30(2), 179-188.
12. Garg, M., & Gupta, S. (2021). Startups and the growing entrepreneurial ecosystem. 17. Misha, V. (2022). Indian Startup Ecosystem–Challenges and Opportunities. International Journal of Research in Science, Commerce, Arts, Management and Technology, 7-1.

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

ROLE OF LIFE SCIENCES IN HIGHER EDUCATION AND SUSTAINABLE DEVELOPMENT

Dr.Balasaheb K.Tapale
Assistant Professor and Head
Department of Zoology
Adv.M.N.Deshmukh Arts, Science and Commerce College Rajur,
Tal-Akole, District – Ahilyanagar (MS) 422604
E-mail: dr.balasahebtapale@gmail.com

Abstract:

Life sciences play a fundamental role in advancing higher education and promoting sustainable development by addressing critical global challenges such as climate change, biodiversity loss, food insecurity, and public health crises. Higher education institutions (HEIs) serve as hubs for knowledge generation, innovation, and capacity building, where life sciences education equips students with scientific understanding and practical skills essential for sustainability (Leal Filho, W. *et al*. (2025). This paper examines the integration of life sciences in higher education and its contribution to environmental, social, and economic sustainability. It also discusses challenges and future directions for enhancing the role of life sciences in achieving sustainable development goals (Aleixo, A. M., *et al.* (2021).

1. Introduction:

Sustainable development has become a central global objective, especially following the adoption of the United Nations' **United Nations Sustainable Development Goals (SDGs)** in 2015. These goals emphasize the need for balanced progress across environmental, social, and economic dimensions (United Nations. (2015).

Higher education institutions are recognized as key contributors to sustainable development because they educate future leaders, generate research, and influence societal practices. Life sciences—encompassing biology, biotechnology, environmental science, and health sciences—provide essential knowledge for understanding natural systems and human interactions with the environment. Their integration into higher education is therefore crucial for building a sustainable future (UNESCO, 2017).

2. Life Sciences in Higher Education

2.1 Interdisciplinary Education: Life sciences promote interdisciplinary learning by integrating fields such as ecology, genetics, microbiology, and environmental science with

policy, economics, and social sciences. Sustainability issues are complex and require such cross-disciplinary approaches (National Research Council, 1999).

Students studying life sciences gain competencies in:

- Ecosystem analysis
- Environmental monitoring
- Disease prevention and control
- Sustainable resource management

This interdisciplinary training prepares graduates to address real-world sustainability challenges (National Academy of Sciences, 2018).

2.2 Research and Innovation: Higher education institutions serve as research centers where life sciences contribute to innovation. Research in areas such as biotechnology, agriculture, and medicine leads to sustainable solutions, including:

- Development of climate-resilient crops
- Renewable bio-based resources
- Advances in healthcare and disease prevention

For example, biotechnology has enabled the development of genetically improved crops that increase productivity while reducing environmental impact (Soam, S. K., *et al.* 2023).

2.3 Skill Development and Employability: Life sciences education enhances employability by equipping students with technical and analytical skills relevant to emerging industries such as biotechnology, pharmaceuticals, and environmental management. These sectors are vital for sustainable economic development (World Economic Forum, 2020).

3. Contribution of Life Sciences to Sustainable Development

3.1 Environmental Sustainability: Life sciences play a critical role in understanding and protecting the environment.

- **Biodiversity Conservation:** Study of ecosystems helps preserve species and habitats.
- **Climate Change Mitigation:** Research on carbon cycles and renewable energy supports climate action.
- **Pollution Control:** Environmental science helps manage waste and reduce pollution.

Higher education institutions incorporate these topics into curricula and research programs to promote environmental sustainability (National Research Council, 2012).

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

3.2 Social Sustainability: Life sciences contribute significantly to improving human well-being and social equity:

- **Public Health:** Advances in medical sciences help control diseases and improve healthcare systems.
- **Food Security:** Agricultural sciences ensure sustainable food production.
- **Nutrition:** Research on nutrition improves quality of life and reduces malnutrition.

The COVID-19 pandemic highlighted the importance of life sciences in managing global health crises (WHO, *Coronavirus,* COVID-19).

3.3 Economic Sustainability: Life sciences contribute to economic growth through innovation and industry development (OECD, 2009).

- Biotechnology and pharmaceutical industries generate employment and economic value.
- Sustainable agriculture supports rural economies.
- Bio-based industries reduce dependence on non-renewable resources (ISAAA, 2022).

Thus, life sciences support a green economy aligned with sustainability principles.

4. Role of Higher Education Institutions (HEIs)

4.1 Curriculum Integration: HEIs integrate sustainability concepts into life sciences education, ensuring that students understand the environmental and societal implications of scientific knowledge.

4.2 Research and Development: Universities conduct research that directly addresses sustainability challenges, including renewable energy, conservation, and healthcare innovations (Leal Filho, W. 2011).

4.3 Community Engagement: HEIs collaborate with communities, industries, and governments to implement sustainable practices and raise awareness.

4.4 Sustainable Campus Practices: Many universities adopt sustainable practices such as energy conservation, waste management, and green infrastructure, serving as models for society.

Challenges: Despite their importance, several challenges hinder the effective integration of life sciences in sustainability:

- Limited interdisciplinary collaboration

- Insufficient funding for research
- Lack of infrastructure and resources
- Inadequate policy support
- Resistance to curriculum changes

Addressing these challenges is essential to maximize the impact of life sciences in higher education (Pohl, C., *et al*. 2017).

Future Directions: To strengthen the role of life sciences in sustainable development, the following steps are recommended (OECD, "The Bioeconomy to 2030: Designing a Policy Agenda" (2009).

- Promote interdisciplinary and problem-based learning
- Increase funding for life sciences research
- Strengthen collaboration between academia, industry, and government
- Integrate sustainability into all levels of education
- Encourage innovation and entrepreneurship in life sciences

Conclusion:

Life sciences are central to higher education and play a vital role in achieving sustainable development. By providing knowledge, fostering innovation, and promoting responsible practices, life sciences education equips individuals to address global challenges effectively. Higher education institutions must continue to integrate life sciences with sustainability principles to build a resilient and sustainable future.

References

1. Aleixo, A. M., et al. (2021). *Higher education for sustainability: A global perspective*.
2. ISAAA, 2022: (International Service for the Acquisition of Agri-biotech Applications) (2022)
3. United Nations (2015). *Transforming our world: The 2030 Agenda for Sustainable Development.*
4. UNESCO (2017). *Education for Sustainable Development Goals: Learning Objectives.*
5. Leal Filho, W. (2011). *About the role of universities and their contribution to sustainable development.*
6. Leal Filho, W. et al. (2025). *Systematic literature review on the sustainability of higher education institutions (HEIs)*
7. Walter Leal Filho et al. (2018). *The role of higher education institutions in sustainability initiatives at the local level.* Journal of Cleaner Production, 182, 100–107

8. World Health Organization (WHO). *Coronavirus (COVID-19) Pandemic* https://www.who.int/emergencies/diseases/novel-coronavirus-2019
9. Lozano, R., et al. (2013). *Barriers to sustainability in higher education.* Journal of Cleaner Production.
10. National Research Council (2012). *A New Biology for the 21st Century*
11. OECD, 2009. *The Bioeconomy to 2030: Designing a Policy Agenda*
12. Soam, S. K., et al. (2023). *Academia–industry linkages for sustainable innovation in agriculture higher education*. Sustainability.
13. Pohl, C., et al. (2017). "Transdisciplinary collaboration in sustainability science: A literature review." *Environmental Science & Policy*, 77, 1-13.
14. World Economic Forum (2020). *The Future of Jobs Report 2020*
15. Tilbury, D. (2011). *Education for Sustainable Development: An Expert Review.* UNESCO.
16. World Health Organization (2020). *Role of life sciences in global health.*
17. FAO (2019). *Sustainable agriculture and food systems.*

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

जागतिकीकरण आणि तांत्रिक ज्ञानाचे हस्तांतरण : उदयोन्मुख अर्थव्यवस्थांचा अभ्यास

प्रा. डॉ. नितीन उल्हास देशमुख

सहाय्यक प्राध्यापक, अर्थशास्त्र विभाग,

अॅड्. मनोहरराव नानासाहेब देशमुख कला, विज्ञान व वाणिज्य महाविद्यालय, राजूर, ता. अकोले, जि. अहिल्यानगर, मो. ९०११२१४००९

Email :- nitindeshmukh5617@gmail.com

प्रस्तावना :-

आज २१ व्या शतकातील जागतिक अर्थव्यवस्था ही केवळ वस्तू आणि सेवांच्या व्यापारापुरती मर्यादित राहिलेली नसून, ती आता 'ज्ञान-आधारित अर्थव्यवस्था' बनली आहे. जागतिकीकरण ही एक अशी प्रक्रिया आहे जिने भौगोलिक सीमा पुसून टाकल्या असून, माहिती, भांडवल आणि तंत्रज्ञानाचा प्रवाह जगभर मुक्तपणे वाहू लागला आहे. या प्रक्रियेतील सर्वात महत्त्वाचा घटक म्हणजे 'तांत्रिक ज्ञानाचे हस्तांतरण' होय.

प्रगत देशांकडे असलेले अद्ययावत तंत्रज्ञान जेव्हा विकसनशील किंवा उदयोन्मुख अर्थव्यवस्थांकडे - जसे की भारत, चीन, ब्राझील - हस्तांतरित होते, तेव्हा त्या देशांच्या विकास प्रक्रियेला मोठी गती मिळते. हे हस्तांतरण केवळ यंत्रसामग्रीच्या स्वरूपात नसून ते तांत्रिक कौशल्ये, व्यवस्थापकीय अनुभव आणि नवनिर्मितीच्या स्वरूपात असते. विदेशी थेट गुंतवणूक, संयुक्त उपक्रम आणि परवाना करार यांसारख्या माध्यमांतून हे ज्ञान स्थानिक उद्योगांपर्यंत पोहोचते.

उदयोन्मुख अर्थव्यवस्थांसाठी तांत्रिक ज्ञानाचे हस्तांतरण हे केवळ एक गरज नसून ते जागतिक बाजारपेठेत टिकून राहण्याचे एक प्रभावी साधन आहे. यामुळे स्थानिक उत्पादकता वाढते, रोजगाराच्या नवीन संधी निर्माण होतात आणि मानवी संसाधनांचा विकास होतो. तथापि, या प्रक्रियेत बौद्धिक संपदा अधिकार, तांत्रिक दरी आणि स्थानिक संशोधन व विकासाचा अभाव यांसारखी आव्हानेही उभी आहेत.

प्रस्तुत शोधनिबंधात जागतिकीकरणाच्या पार्श्वभूमीवर तांत्रिक ज्ञानाच्या हस्तांतरणाचे स्वरूप, त्याचे उदयोन्मुख अर्थव्यवस्थांवरील सकारात्मक व नकारात्मक परिणाम आणि भविष्यातील संधी यांचा सविस्तर अभ्यास करण्याचा प्रयत्न केला आहे.

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

मूळ शब्द (Keywords) **:-** जागतिकीकरण, तंत्रज्ञान हस्तांतरण, उदयोन्मुख अर्थव्यवस्था, आर्थिक विकास, विदेशी गुंतवणूक, कौशल्य विकास.

उद्दिष्ट्ये :-

प्रस्तुत या संशोधनाचे प्रमुख उद्दिष्टे खालीलप्रमाणे आहेत:

१. जागतिकीकरण आणि तांत्रिक ज्ञान हस्तांतरण यांच्यातील संबंध समजून घेणे.

२. उदयोन्मुख अर्थव्यवस्थांमध्ये तंत्रज्ञान हस्तांतरणाची भूमिका अभ्यासणे.

३. बहुराष्ट्रीय कंपन्या आणि परकीय गुंतवणुकीचा तंत्रज्ञान प्रसारावर होणारा परिणाम समजून घेणे.

४. जागतिकीकरणामुळे उदयोन्मुख अर्थव्यवस्थांच्या आर्थिक विकासावर होणाऱ्या परिणामांचा अभ्यास करणे.

गृहीतक :-

१. आधुनिक विपणन पद्धती पारंपरिक विपणन पद्धतींपेक्षा अधिक प्रभावी ठरतात.

२. डिजिटल विपणनामुळे ग्राहकांशी थेट संवाद साधणे शक्य होते .

संशोधन साहित्ये :-

प्रस्तुत संशोधनासाठी "जागतिकीकरण आणि तांत्रिक ज्ञानाचे हस्तांतरण : उदयोन्मुख अर्थव्यवस्थांचा अभ्यास" या विषयाची निवड करण्यात आलेली आहे. सदर संशोधनासाठी द्वितीय माहिती स्त्रोतांचा अवलंब करण्यात आला आहे. संशोधनासाठी लागणारी दुय्यम साधन सामुग्री आधुनिक अर्थशास्त्र विषयाचे विविध संदर्भ ग्रंथ, पुस्तके, मासिके तसेच वर्तमानपत्रे, आधुनिक अर्थशास्त्र विषयासंबधित विविध संकेतस्थळे इत्यादी द्वारे प्रस्तुत संशोधानीची माहिती जमा करण्यात आलेली आहे. या सर्व स्रोतांचा अभ्यास करून विश्लेषणात्मक पद्धतीने निष्कर्ष काढण्यात आले आहेत.

साहित्याचे पुनरावलोकन (Review of Literature)

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

जागतिकीकरण व तांत्रिक ज्ञानाचे हस्तांतरण : उदयोन्मुख अर्थव्यवस्थांचा अभ्यास" या विषयाच्या साहित्य पुनरावलोकनात पुढील काही शास्त्रज्ञ व त्यांचे लेख / संशोधन उल्लेख करता येतात.

जोसेफ स्टिग्लिट्झ – जागतिकीकरण आणि त्याचे असंतोष या लेखनात त्यांनी जागतिकीकरणामुळे तंत्रज्ञान व ज्ञान विकसनशील देशांपर्यंत पोहोचते असे सांगितले आहे. थॉमस एल. फ्रिडमन – जग सपाट झाले आहे या पुस्तकात माहिती तंत्रज्ञान व जागतिकीकरणामुळे ज्ञानाची देवाणघेवाण वेगाने वाढल्याचे स्पष्ट केले आहे. पॉल रोमेर – अंतर्जात वाढ सिद्धांत त्यांच्या सिद्धांतानुसार तांत्रिक ज्ञान आणि नवकल्पना आर्थिक वाढीचे मुख्य घटक आहेत. रॉबर्ट लुकास – आर्थिक विकासातील मानवी भांडवलाची भूमिका त्यांनी मानवी कौशल्ये व शिक्षणामुळे तांत्रिक ज्ञानाचा प्रसार होतो असे मांडले आहे. डेव्हिड ऑटर – तंत्रज्ञान आणि रोजगारातील बदल त्यांच्या अभ्यासात आधुनिक तंत्रज्ञानामुळे उत्पादनक्षमता आणि उद्योगातील बदल स्पष्ट केले आहेत. डॅनियल आर्चीबुगी आणि जोनाथन मिची – तंत्रज्ञानाचे जागतिकीकरण या लेखात जागतिकीकरणामुळे संशोधन, नवकल्पना आणि तंत्रज्ञानाचा जागतिक प्रसार कसा होतो याचे विश्लेषण केले आहे. संजय लल्ल – विकसनशील देशांतील तांत्रिक क्षमता त्यांनी उदयोन्मुख अर्थव्यवस्थांमध्ये तांत्रिक कौशल्य विकसित करण्याचे महत्त्व सांगितले आहे.

वरील शास्त्रज्ञांच्या अभ्यासानुसार जागतिकीकरणामुळे तांत्रिक ज्ञानाचा प्रसार वेगाने होतो आणि त्यामुळे उदयोन्मुख अर्थव्यवस्थांमध्ये औद्योगिक विकास, उत्पादनक्षमता आणि नवकल्पना वाढतात.

विश्लेषण :-

जागतिकीकरणाची संकल्पना :-

जागतिकीकरण म्हणजे जगातील विविध देशांमधील आर्थिक, सामाजिक, सांस्कृतिक आणि तांत्रिक संबंधांची वाढती परस्परावलंबन प्रक्रिया होय. या प्रक्रियेमुळे वस्तू, सेवा, भांडवल, तंत्रज्ञान, माहिती आणि मनुष्यबळ यांचा आंतरराष्ट्रीय स्तरावर मुक्त प्रवाह होऊ लागतो. जागतिकीकरणामुळे देशांमधील व्यापार वाढतो, परकीय गुंतवणूक वाढते आणि विविध देशांतील लोक, संस्था व कंपन्या एकमेकांशी अधिक जवळीक साधतात. आधुनिक माहिती व संप्रेषण तंत्रज्ञान, इंटरनेट, वाहतूक व्यवस्था आणि आंतरराष्ट्रीय व्यापार करार यांमुळे जागतिकीकरणाची प्रक्रिया अधिक वेगाने घडत आहे. सोप्या शब्दांत सांगायचे झाल्यास, जगातील सर्व देश

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

आर्थिक आणि तांत्रिकदृष्ट्या एकमेकांशी जोडले जाण्याची प्रक्रिया म्हणजे जागतिकीकरण होय. विद्वानांच्या मते जागतिकीकरण पुढीलप्रमाणे.

ॲन्थनी गिडेन्स :- जागतिकीकरण म्हणजे जगातील दूरवर असलेल्या समाजांना एकमेकांशी जोडणारी प्रक्रिया होय.

जोसेफ स्टिग्लिट्झ :- जागतिकीकरण म्हणजे आंतरराष्ट्रीय व्यापार, गुंतवणूक आणि तंत्रज्ञान प्रसारामुळे देशांमधील आर्थिक एकात्मता वाढण्याची प्रक्रिया होय.

जागतिकीकरणामुळे आंतरराष्ट्रीय व्यापारात वाढ, परकीय गुंतवणुकीत वाढ, तंत्रज्ञान आणि माहितीचा जलद प्रसार, बहुराष्ट्रीय कंपन्यांचा विस्तार, सांस्कृतिक देवाणघेवाण होण्यास मदत होत असते.

यावरून असे समजते कि, जागतिकीकरण ही आधुनिक जगातील एक महत्त्वाची प्रक्रिया असून ती आर्थिक विकास, तंत्रज्ञान प्रसार आणि आंतरराष्ट्रीय सहकार्य वाढविण्यासाठी महत्त्वाची भूमिका बजावते.

तांत्रिक ज्ञानाचे हस्तांतरण

तांत्रिक ज्ञान हस्तांतरण म्हणजे एका देशात विकसित झालेले तंत्रज्ञान, कौशल्ये, उत्पादन पद्धती आणि संशोधन दुसऱ्या देशात पोहोचण्याची प्रक्रिया होय. ही प्रक्रिया अनेक मार्गांनी घडते:

उदाहरण :- परकीय थेट गुंतवणूक (FDI), बहुराष्ट्रीय कंपन्या, आंतरराष्ट्रीय व्यापार, संशोधन व विकास सहकार्य, शिक्षण आणि प्रशिक्षण

या माध्यमांद्वारे विकसित देशांतील आधुनिक तंत्रज्ञान विकसनशील आणि उदयोन्मुख अर्थव्यवस्थांमध्ये पोहोचते.

जागतिकीकरण आणि तंत्रज्ञान प्रसार

जागतिकीकरणामुळे देशांमधील तांत्रिक ज्ञानाचा प्रसार जलद होतो. आंतरराष्ट्रीय व्यापार, जागतिक मूल्य साखळी आणि बहुराष्ट्रीय कंपन्या या तंत्रज्ञान हस्तांतरणाच्या प्रमुख माध्यमे आहेत. अनेक संशोधनांनुसार जागतिकीकरणामुळे डिजिटल तंत्रज्ञानाचा स्वीकार वाढतो आणि उत्पादकता व नवोन्मेषात वाढ होते. जागतिक

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

बाजारपेठेमुळे कंपन्यांना नवीन तंत्रज्ञान विकसित करण्यासाठी प्रोत्साहन मिळते आणि त्याचा फायदा इतर देशांनाही होतो.

उदयोन्मुख अर्थव्यवस्थांची संकल्पना

उदयोन्मुख अर्थव्यवस्था (Emerging Economies) ही संकल्पना जागतिक अर्थशास्त्रात अत्यंत महत्त्वाची आहे. अशा अर्थव्यवस्था ज्या आता 'विकसनशील' राहिल्या नाहीत, पण अजून पूर्णपणे 'विकसित' देखील झालेल्या नाहीत, त्यांना 'उदयोन्मुख अर्थव्यवस्था' म्हणतात.

उदयोन्मुख अर्थव्यवस्था म्हणजे असा देश ज्याची अर्थव्यवस्था वेगाने वाढत आहे आणि जिथे औद्योगिकीकरण व आधुनिकीकरणाची प्रक्रिया तीव्र गतीने सुरू आहे. या देशांमध्ये गुंतवणूकदारांसाठी मोठ्या संधी असतात, पण सोबतच काही प्रमाणात राजकीय आणि आर्थिक जोखीमही असते.

उदयोन्मुख अर्थव्यवस्थांची उदाहरणे

अ) BRICS गट

१. भारत :जगातील सर्वात वेगाने वाढणारी मोठी अर्थव्यवस्था सेवा क्षेत्र आणि तरुण .

२. चीन जगाचा कारखाना :म्हणून ओळखला जाणारा देश जरी आता विकास दर थोडा . मंदावला असला, तरी चीन ही एक महासत्ता आहे.

३. ब्राझील :नैसर्गिक संसाधने आणि कृषी उत्पादनांमध्ये अग्रेसर असलेली दक्षिण अमेरिकेतील मोठी अर्थव्यवस्था.

४. रशिया :ऊर्जा स्त्रोत) तेल आणि वायू (आणि खनिज संपत्तीवर आधारित अर्थव्यवस्था.

५. दक्षिण आफ्रिका :आफ्रिका खंडातील आर्थिक आणि औद्योगिकदृष्ट्या प्रगत देश.

ब) आशियाई वाघ (The Asian Tigers - Next Generation)

१. व्हिएतनाम.उत्पादनासाठी चीनला पर्याय म्हणून वेगाने पुढे येत असलेला देश :

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

२. इंडोनेशिया :आग्नेय आशियातील सर्वात मोठी अर्थव्यवस्था आणि नैसर्गिक साधनसंपत्तीने समृद्ध देश.

क) इतर महत्त्वाची उदाहरणे

१. मेक्सिको :अमेरिकेशी असलेल्या व्यापार करारामुळे) USMCA) उत्पादन क्षेत्रात मोठी प्रगती करत आहे.

२. तुर्की :युरोप आणि आशियाच्या सीमेवर असलेले एक महत्त्वाचे व्यापारी केंद्र.

तंत्रज्ञान हस्तांतरणाचे प्रमुख मार्ग

१. परकीय थेट गुंतवणूक)FDI) -: परकीय कंपन्या जेव्हा दुसऱ्या देशात गुंतवणूक करतात तेव्हा त्या आधुनिक तंत्रज्ञान आणि व्यवस्थापन पद्धती घेऊन येतात.

२. बहुराष्ट्रीय कंपन्या -: बहुराष्ट्रीय कंपन्या विविध देशांमध्ये उत्पादन केंद्र स्थापन करतात . .त्यामुळे स्थानिक कंपन्यांना नवीन तंत्रज्ञान शिकण्याची संधी मिळते

३. जागतिक मूल्य साखळी -: उत्पादन प्रक्रियेतील विविध टप्पे वेगवेगळ्या देशांमध्ये पूर्ण केले जातात .या प्रक्रियेमुळे ज्ञान आणि कौशल्यांचे हस्तांतरण होते .

४. संशोधन आणि विकास सहकार्य -: विविध देशांतील संशोधन संस्था आणि विद्यापीठे एकत्र येऊन नवीन तंत्रज्ञान विकसित करतात.

उदयोन्मुख अर्थव्यवस्थांवर तंत्रज्ञान हस्तांतरणाचा प्रभाव

१. औद्योगिक विकास -: नवीन तंत्रज्ञानामुळे उत्पादन प्रक्रिया अधिक कार्यक्षम बनते आणि उद्योगांचा विस्तार होतो.

२. उत्पादकता वाढ -: परकीय तंत्रज्ञानाचा वापर केल्यामुळे उत्पादन खर्च कमी होतो आणि उत्पादनक्षमता वाढते.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

३. नवोन्मेष -: जागतिक स्पर्धेमुळे कंपन्या नवीन उत्पादने आणि सेवा विकसित करण्यासाठी प्रेरित होतात.

४. आर्थिक विकास -: तंत्रज्ञान हस्तांतरणामुळे देशाचा GDP वाढतो आणि आर्थिक प्रगती होते.

डिजिटल अर्थव्यवस्था आणि ज्ञान प्रसार

डिजिटल तंत्रज्ञानामुळे ज्ञान प्रसाराचा वेग मोठ्या प्रमाणात वाढला आहे. इंटरनेट, क्लाउड कम्प्युटिंग आणि कृत्रिम बुद्धिमत्ता यांसारख्या तंत्रज्ञानामुळे माहिती सहज उपलब्ध झाली आहे.

डिजिटल अर्थव्यवस्था जागतिक GDP च्या मोठ्या भागात योगदान देत असून ती पारंपरिक अर्थव्यवस्थेपेक्षा वेगाने वाढत आहे.

भारतातील तंत्रज्ञान विकास

भारताने जागतिकीकरणाचा प्रभावी वापर करून माहिती तंत्रज्ञान आणि डिजिटल सेवा क्षेत्रात मोठी प्रगती साधली आहे.

उदाहरणे : IT उद्योगाचा विकास, स्टार्टअप संस्कृती, डिजिटल इंडिया अभियान, ई-गव्हर्नन्स

या उपक्रमांमुळे भारत जागतिक डिजिटल अर्थव्यवस्थेत महत्त्वाची भूमिका बजावत आहे.

जागतिकीकरणाचे सकारात्मक परिणाम

तंत्रज्ञानाचा जलद प्रसार, आर्थिक विकास, नवोन्मेष आणि संशोधन वाढ, रोजगार निर्मिती, जागतिक सहकार्य याप्रमाणे जागतिकीकरणाचे अनेक सकारात्मक परिणाम आहेत.

जागतिकीकरणाचे नकारात्मक परिणाम

विकसित आणि विकसनशील देशांमधील तांत्रिक अंतर, स्थानिक उद्योगांवर जागतिक, स्पर्धेचा दबाव, बौद्धिक संपदा हक्कांचे प्रश्न, कौशल्य असमानता यांसारखे जागतिकीकरणाचे नकारात्मक परिणाम देखील आहेत.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

सकारात्मक आणि नकारात्मक परिणामाचा ताळमेळ घालून आपण किंवा राष्ट्रांनी आपली प्रगती करणे अपेक्षित आहे.

उदयोन्मुख अर्थव्यवस्थांसमोरील आव्हाने

- संशोधन आणि विकासासाठी कमी गुंतवणूक
- कुशल मनुष्यबळाची कमतरता
- तंत्रज्ञानावर परकीय अवलंबित्व
- पायाभूत सुविधांची मर्यादा

धोरणात्मक उपाय

उदयोन्मुख अर्थव्यवस्थांनी पुढील उपाययोजना करणे आवश्यक आहे:

१. संशोधन व विकासासाठी अधिक गुंतवणूक
२. उच्च शिक्षण आणि कौशल्य विकास वाढवणे
३. स्थानिक नवोन्मेषाला प्रोत्साहन
४. डिजिटल पायाभूत सुविधा विकसित करणे
५. उद्योगविद्यापीठ सहकार्य वाढवणे-

निष्कर्ष

जागतिकीकरणामुळे जगातील देशांमधील तंत्रज्ञान आणि ज्ञानाचा प्रसार मोठ्या प्रमाणात वाढला आहे. या प्रक्रियेमुळे उदयोन्मुख अर्थव्यवस्थांना आधुनिक तंत्रज्ञान मिळण्याची संधी मिळाली आहे. परकीय गुंतवणूक, बहुराष्ट्रीय कंपन्या आणि जागतिक मूल्य साखळी यांद्वारे तंत्रज्ञान हस्तांतरण होत असून त्यामुळे उद्योग, उत्पादन आणि सेवा क्षेत्रात मोठी प्रगती झाली आहे.

मात्र या प्रक्रियेमुळे काही आव्हाने देखील निर्माण झाली आहेत. त्यामुळे उदयोन्मुख अर्थव्यवस्थांनी शिक्षण, संशोधन आणि नवोन्मेष यांना प्रोत्साहन देऊन तंत्रज्ञान हस्तांतरणाचा अधिक फायदा करून घ्यावा.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

संदर्भ सूची (References) :-

पुस्तके :-

१. भगत, आर. (२०१८). जागतिकीकरण आणि भारतीय अर्थव्यवस्था. पुणे: डायमंड पब्लिकेशन्स.

२. कुलकर्णी, एस. (२०२०). आधुनिक अर्थशास्त्र. मुंबई: हिमालय पब्लिशिंग हाऊस.

३. पाटील, व्ही. (२०१९). आंतरराष्ट्रीय व्यापार आणि अर्थव्यवस्था. कोल्हापूर: फडके प्रकाशन.

४. देशपांडे, एम. (२०१७). जागतिकीकरण: संकल्पना आणि परिणाम. पुणे: मेहता पब्लिशिंग हाऊस.

५. जोशी, ए. (२०१६). विकसनशील आणि उदयोन्मुख अर्थव्यवस्था. नागपूर: विद्या प्रकाशन.

६. Behera, N. C. (2021). Globalization, deglobalization and knowledge production. International Affairs, 97(5), 1579–1597.

७. Chen, Q., & Li, Y. (2019). Mobility, knowledge transfer and innovation: An empirical study on returned Chinese academics. Sustainability, 11(22), 6454.

८. Compagnucci, L., & Spigarelli, F. (2024). Improving knowledge transfer and innovation services: A roadmap for knowledge transfer offices. Journal of Innovation & Knowledge, 9(1).

९. Eugster, J. L., Ho, G., Jaumotte, F., & Piazza, R. (2021). International knowledge spillovers. Journal of Economic Geography, 22(6), 1191–1216.

वर्तमानपत्रे :-

१. पाटील, एस. (२०२३, जून १५). जागतिकीकरणामुळे भारतीय उद्योगांना नवी दिशा. लोकसत्ता.

२. देशमुख, आर. (२०२२, ऑगस्ट १०). उदयोन्मुख अर्थव्यवस्था आणि भारताची भूमिका. सकाळ.

३. शिंदे, ए. (२०२१, डिसेंबर ५). तंत्रज्ञान विकासामुळे अर्थव्यवस्थेत बदल. महाराष्ट्र टाइम्स.

४. जाधव, पी. (२०२०, मार्च १२). जागतिक व्यापार आणि भारताची अर्थव्यवस्था. लोकमत.

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

संकेतस्थळे :-

१. International Monetary Fund. (२०२१). World economic outlook. International Monetary Fund. https://www.imf.org

२. World Economic Forum. (२०१८). Globalization and innovation. World Economic Forum. https://www.weforum.org

३. investment report. UNCTAD. https://unctad.org

४. भारत सरकार वित्त मंत्रालय. (२०२३). आर्थिक सर्वेक्षण भारत. https://www.indiabudget.gov.in

५. महाराष्ट्र शासन. (२०२२). महाराष्ट्र आर्थिक सर्वेक्षण. https://mahades.maharashtra.gov.in

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

GREEN CAMPUSES AND SUSTAINABLE UNIVERSITIES: INSTITUTIONAL PRACTICES FOR ENVIRONMENTAL RESPONSIBILITY

Mr. Santosh D.Chippadi[1] and Mr.Basavaraj Dhavaleshwar[2]
Research Scholar,
Rani Channamma University, Belagavi

Abstract

This study examines how Indian higher education institutions are implementing green campus practices and what those practices actually achieve. The research covers ten institutions and draws on campus audits, 65 interviews, and surveys of 520 students and staff. It looks at five areas: energy management, water conservation, waste reduction, green infrastructure, and curriculum integration.

The findings are mixed. Institutions with dedicated sustainability leadership and broad stakeholder involvement produce measurably better outcomes than those treating sustainability as a facilities management function. Solar installations across surveyed institutions generated over 12,000 MWh of renewable energy annually. Water conservation programs achieved reductions of 35–50% in consumption at institutions with comprehensive management systems. Waste diversion rates of 60–80% from landfills were recorded at institutions with serious composting and recycling programs.

The research also finds that financial investment above a basic threshold matters less than leadership quality and stakeholder engagement, which has practical implications for resource-constrained institutions. Barriers are real: funding gaps, shortage of technical expertise, and staff resistance to changed practices all limit implementation. The paper concludes with recommendations for institutions at different stages and resource levels, rather than a single prescription.

Keywords: *Green Campus, Campus Sustainability, Higher Education, Environmental Management, Renewable Energy, Waste Management, India*

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

1. Introduction

Universities are large institutions. They consume significant energy, generate substantial waste, use considerable water, and occupy land that shapes local ecosystems. That operational footprint is often discussed abstractly, but it is real and measurable — and it makes higher education institutions legitimate targets for environmental improvement, not just environmental advocacy.

The Indian higher education system includes over 1,000 universities and more than 42,000 colleges. Even modest improvements in environmental performance across that system would produce meaningful aggregate effects. The government has recognized this through the UGC's green campus guidelines and India's National Action Plan on Climate Change, both of which create policy pressure for institutional action. What policy pressure creates, however, is not always implementation. The gap between a guideline and a functioning composting system, or between a solar policy and installed panels, is wide and depends on institutional-level decisions that policy cannot fully specify.

This study examines that gap. It looks at what ten Indian institutions are actually doing on environmental sustainability, which practices are producing measurable results, what is limiting progress, and how successful approaches can be adapted for different institutional contexts. The aim is not to describe an ideal green campus but to understand what works under real conditions.

2. Objectives of the Study

Primary Objectives

1. To identify and analyze green campus sustainability initiatives implemented by Indian higher education institutions.
2. To evaluate the effectiveness of these practices in achieving environmental and educational outcomes.
3. To develop evidence-based recommendations for scaling sustainable campus practices across diverse institutional contexts.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Secondary Objectives

4. To examine the relationship between sustainability practices and institutional performance.
5. To identify challenges and barriers in implementing green campus initiatives.
6. To explore the role of student and faculty engagement in sustainability programs.
7. To analyze the integration of sustainability into curriculum and research activities.
8. To assess the alignment between campus practices and broader environmental goals.

3. Research Methodology

The study used an explanatory sequential mixed-methods design. Qualitative fieldwork came first — mapping what institutions were doing and why — followed by quantitative analysis to assess outcomes and identify patterns. The two strands were used together rather than in parallel, with qualitative findings shaping what the quantitative instruments measured.

Case Selection

Ten institutions were selected to represent variation in institutional type (central universities, state universities, technical institutions), geographic region (North, South, East, West, Central India), program maturity, and available resources. The variation was intentional: an analysis confined to well-resourced, high-performing institutions would not say much about what is achievable across the system.

Data Collection

Four methods were used. Document analysis covered sustainability reports, environmental policies, infrastructure plans, and energy consumption data. Semi-structured interviews (65 total) were conducted with administrators, facilities managers, faculty, and student sustainability leaders. Structured questionnaires went to 520 students and staff covering awareness, engagement, and perceived program effectiveness. Physical campus audits were conducted at each institution, including direct measurement of energy consumption, water usage, waste generation, and on-site inspection of green infrastructure. The audit data is worth

emphasizing: much campus sustainability research relies on self-reported information, which tends to overstate performance. Direct measurement produces different numbers.

Analysis

Qualitative data were analyzed using Braun and Clarke's (2006) thematic analysis framework. Quantitative data were processed in SPSS using descriptive statistics, correlation analysis, and regression modeling. Where audit data conflicted with self-reported data from questionnaires or interviews, the audit figures were used and the discrepancy noted.

4. Literature Review

Theoretical Frameworks

Campus sustainability research draws on two frameworks worth flagging explicitly. Ecological modernization theory holds that environmental protection and economic development are not fundamentally in tension: through technological innovation, institutional learning, and deliberate planning, organizations can reduce environmental impact while maintaining or improving operational performance. The campus sustainability literature largely supports this view. Energy efficiency improvements typically produce cost savings. Waste reduction programs often generate revenue through recycling. The idea that sustainability requires sacrifice is not well-supported by the evidence from institutions that have actually implemented programs.

The broader sustainability science framework emphasizes that environmental, social, and economic dimensions of development are interconnected and need to be addressed together rather than sequentially. For campus sustainability, this means that a solar panel installation is not just an energy decision; it also has implications for what students learn, how staff relate to institutional values, and what the institution signals to its community. Programs designed with only the energy dimension in mind tend to underperform on the others.

International Models

The STARS (Sustainability Tracking, Assessment and Rating System) framework, developed by AASHE, provides a standardized approach to evaluating campus sustainability across academics, operations, planning, and engagement. Its value is not primarily the rating it

produces but the inventory process, which forces institutions to measure things they often do not track. Many Indian institutions have adopted elements of STARS or similar frameworks without formally participating in the rating system, using them as internal planning tools.

The Second Nature Climate Commitment (formerly the College and University Presidents' Climate Commitment) offers a model for institutional climate action planning, including greenhouse gas inventories and mitigation strategies. Its relevance to the Indian context is partial — it was designed for US institutions with different resource profiles — but the basic approach of committing to measurable targets and tracking progress against them translates reasonably well.

The Indian Context

Implementation across Indian institutions is uneven in ways that matter for this research. IITs and IIMs have developed comprehensive sustainability programs, with dedicated staff, significant capital investment, and measurable outcomes. Many regional colleges have neither the resources nor the institutional attention to pursue more than compliance with minimum requirements. The research needed to account for this range rather than treating 'Indian higher education' as a single category.

The UGC's green campus guidelines create a policy environment that is supportive but not prescriptive. Institutions are expected to reduce environmental impact but have significant latitude in how. This is appropriate given the diversity of the system, but it also means that progress depends heavily on whether individual institutions choose to act seriously.

Energy

Educational institutions account for an estimated 10–15% of total energy consumption in many countries, making them a meaningful target for efficiency improvements. The cost of solar photovoltaic systems has fallen by over 80% in the past decade, which has shifted the economics of campus solar from aspirational to straightforwardly viable for most institutions with adequate roof space or land. The remaining barriers are not primarily financial in well-resourced institutions; they are organizational — procurement processes, facilities management capacity, and the difficulty of managing construction projects without disrupting academic operations.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Waste and Water

Campus waste programs that achieve meaningful diversion rates typically combine source reduction, recycling, composting, and properly managed disposal of hazardous materials including laboratory chemicals and e-waste. Programs that focus only on visible waste streams (paper, plastic) while leaving food waste and hazardous materials unaddressed achieve partial results. The circular economy framing — treating waste as a resource to be recovered rather than a problem to be disposed of — has influenced program design at the more advanced institutions in this study.

Water is a particularly pressing issue in water-stressed parts of India, where some campuses draw heavily on groundwater. Institutions with comprehensive water management programs — combining rainwater harvesting, graywater recycling, water-efficient fixtures, and leak detection — show substantially lower per-capita consumption than those with only one or two measures in place. The combination matters; individual measures in isolation produce modest effects.

Curriculum Integration

The literature consistently finds that sustainability programs are more durable and more effective when they are connected to academic work rather than treated as separate operational initiatives. Students who work on campus sustainability projects as part of coursework develop stronger environmental competencies and are more likely to continue sustainability-related behavior after graduation. Faculty research on campus systems creates knowledge that improves program design. The operational and educational dimensions of campus sustainability are not competing priorities; they reinforce each other when integration is deliberate.

5. Green Campus Initiatives in Higher Education

Renewable Energy

Solar energy is now the dominant renewable technology on Indian campuses, ranging from small rooftop arrays on individual buildings to large ground-mounted installations. Government incentives through the Solar Energy Corporation of India have reduced

installation costs further and provided technical support for institutions without in-house expertise. The institutions in this study with the largest solar installations are not uniformly the wealthiest: several mid-tier state universities have made solar investment a priority and achieved high renewable energy fractions as a result.

Wind and biomass installations are less common and more context-dependent. Some institutions in suitable geographic locations have integrated small wind turbines, in some cases combining energy generation with student research. Biogas systems processing canteen and laboratory organic waste are operating at several institutions, providing cooking fuel while reducing waste volumes.

Waste Management

Institutions with comprehensive waste programs work across multiple streams rather than focusing on any single one. Source reduction through procurement policy changes (defaulting to double-sided printing, reducing single-use plastic procurement, shifting to digital document management) reduces volumes before they become a disposal problem. Recycling infrastructure needs to be visible, clearly labeled, and convenient to actually change behavior — institutions that installed collection points in inconvenient locations found them underused regardless of awareness campaigns.

Composting is where the gap between stated intention and operational reality is widest. Several institutions report composting programs in their sustainability documents; on-site audits found that fewer than half had functioning operations. The ones that work have a dedicated member of staff responsible for the system, regular maintenance schedules, and a clear use pathway for the compost output (typically campus landscaping). The ones that have failed typically delegated responsibility to contractors without adequate oversight.

Hazardous waste — laboratory chemicals, electronic waste, batteries — is the area most frequently neglected in campus sustainability reporting and the area with the most serious environmental risk. Several institutions in the study had no documented hazardous waste management procedure. This is a compliance issue as much as a sustainability one.

Water Management

Rainwater harvesting is widely present across the institutions studied, though installation quality varies. Well-maintained systems with adequate storage capacity and filtration contribute meaningfully to campus water budgets; poorly maintained systems with silted collection channels contribute little. As with composting, the difference is usually maintenance commitment rather than initial installation quality.

Graywater recycling for landscape irrigation is less common but, where implemented, achieves significant reductions in fresh water demand. Several institutions have also moved to xeriscaping in parts of their campus — replacing water-intensive ornamental planting with drought-tolerant native species — which reduces irrigation demand substantially while also improving local biodiversity.

Green Infrastructure

New construction on campuses is increasingly incorporating passive design principles, energy-efficient HVAC systems, LED lighting, and in some cases building automation that adjusts energy use based on occupancy. LEED certification is being pursued by a growing number of institutions, though the certification process itself requires technical expertise and documentation effort that strains facilities staff at smaller institutions.

Smart campus technologies — real-time energy monitoring, automated leak detection, building management systems — are in place at several institutions and consistently produce measurable reductions in resource consumption. The challenge is that these systems require trained staff to interpret the data and act on it, which not all institutions have.

Sustainable Transportation

Campus transportation programs have varied significantly in ambition and effectiveness. Bicycle infrastructure improvements are relatively low-cost and well-received where campuses are laid out in ways that make cycling practical. Electric vehicle charging stations are being installed at several institutions ahead of significant EV adoption, in anticipation rather than in response to demand. Campus shuttle partnerships with public transit providers have reduced single-occupancy vehicle trips at a few urban institutions.

6. Role of Higher Education in Environmental Responsibility

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Research

Campus sustainability initiatives are most valuable as research sites when they are designed with that purpose in mind. A solar installation that generates energy is useful; a solar installation that generates energy and serves as a testbed for performance monitoring research under Indian climate conditions is more valuable. Several institutions in the study have explicitly connected infrastructure investments to faculty research programs, creating arrangements where facilities improvements and academic work reinforce each other.

Curriculum

The gap between institutions that have integrated sustainability into their curricula and those that have not is visible in student behavior data. Students at institutions where sustainability appears in coursework — not just in elective environmental studies classes but across engineering, management, and science programs — show higher scores on environmental awareness measures and report more sustained behavior change after graduation. The effect is not primarily about information: students at all institutions have roughly similar factual knowledge about environmental issues. The difference is in the experience of working on real sustainability problems, which develops judgment rather than just awareness.

Community Engagement

The institutions in this study that have extended their sustainability work beyond campus boundaries have done so most effectively through sustained partnerships rather than one-off events. Training programs for local farmers on sustainable agricultural practices, technical assistance to small businesses on waste reduction, and collaborative environmental monitoring projects with local government agencies all create relationships that persist and produce cumulative benefits. Annual tree-planting events that are not connected to longer-term programs tend to produce photographs rather than forests.

Policy Influence

Several institutions have contributed faculty expertise and research evidence to policy processes at state and national level, particularly on renewable energy standards and waste management regulations. This is a legitimate and important role that most institutions

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

underinvest in relative to their potential contribution. The credibility that comes from having demonstrably implemented what you are recommending is significant in policy contexts.

7. Conceptual Framework

The framework proposed here has four interconnected domains. The first is the practices domain: the specific sustainability initiatives an institution implements, covering energy, waste, water, infrastructure, and transportation. The second is the institutional support domain: leadership commitment, governance, financial resources, technical capacity, and the cultural environment around sustainability. The third is the environmental outcomes domain: measurable changes in energy consumption, water use, waste generation, emissions, and ecological quality. The fourth is the educational and social outcomes domain: changes in student competencies, staff behavior, community engagement, and institutional reputation.

The framework's main implication is that these domains need to be addressed together. Institutions that invest heavily in the first domain (installing solar panels, building composting systems) without attending to the second (training staff, building maintenance capacity, establishing accountability) typically see their infrastructure underperform. Institutions that attend to institutional culture without making concrete investments in physical infrastructure have little to show their community. And institutions that do not connect operational sustainability to educational programs miss the opportunity to make their campus a genuine learning resource.

The framework also implies that sustainability is a continuous management challenge, not a project with a completion date. Energy consumption changes as buildings age, as equipment is replaced, and as campus population shifts. Waste programs need adjustment as waste composition changes. The institutions that sustain strong performance over time are those that treat sustainability as an ongoing operational function with dedicated staff and regular review, not as a campaign that runs until it succeeds.

8. Findings and Discussion

Environmental Outcomes

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

The institutions implementing integrated sustainability programs show average reductions of 25–40% in energy consumption per square meter compared to conventional campus buildings. Solar installations across surveyed institutions generated over 12,000 MWh of renewable energy annually, corresponding to approximately 8,400 metric tons of avoided greenhouse gas emissions. These are real numbers, though it is worth noting that they represent the better-performing institutions in the sample; average performance across all ten is lower.

Water conservation programs achieved reductions of 35–50% in consumption at institutions with comprehensive management systems. Rainwater harvesting systems collectively captured over 2.5 million liters annually across participating institutions. Waste diversion rates of 60–80% from landfills were recorded at institutions with functioning composting and recycling programs. Composting operations processed over 150 tons of organic waste annually across the sample.

The variation within these ranges is as informative as the averages. An institution achieving 50% water reduction and one achieving 35% are not implementing the same program with different resources; they are making different institutional choices about maintenance, staff assignment, and monitoring. The upper end of the range represents what is achievable; the lower end represents what happens when the program exists on paper but not in operation.

What Drives Success

Leadership commitment is the strongest single predictor of sustainability program performance. Institutions with dedicated sustainability officers — not just a faculty member with a sustainability portfolio alongside a full teaching load, but a staff member whose primary responsibility is sustainability management — report 68% higher implementation success rates. This finding is consistent across institution types and resource levels. A well-resourced institution with weak leadership on sustainability consistently underperforms a moderately resourced institution with strong, dedicated leadership.

Stakeholder engagement, particularly active student involvement, correlates strongly with program quality and durability. Student sustainability committees that have genuine influence over program design (rather than just communication roles) produce better programs and maintain them more consistently through staff and faculty turnover. When a sustainability

initiative lives primarily in the knowledge and commitment of one or two individuals, it tends not to survive their departure.

Financial resources matter up to a threshold. Below that threshold — roughly, institutions that cannot fund a dedicated sustainability position or make basic infrastructure investments — resource constraints genuinely limit what is possible. Above it, additional financial investment produces diminishing returns compared to improvements in leadership quality, stakeholder engagement, and maintenance systems. This is practically useful because it means resource-constrained institutions are not categorically excluded from meaningful progress.

Challenges

Funding remains the most commonly cited barrier, particularly for capital-intensive investments like large solar installations and green building construction. Public institutions with constrained budgets often lack access to the upfront capital that would pay back through long-term energy savings, even when the financial case is straightforward. Government incentive programs help but do not fully close this gap.

Technical expertise is a real constraint at institutions without engineering or environmental science departments. Installing a building automation system or designing a graywater recycling system requires knowledge that facilities staff at many regional colleges do not have. Several institutions have addressed this by partnering with nearby technical institutions, using students and faculty as both technical resource and beneficiary.

Behavioral change is the slowest and most frustrating part of sustainability implementation. Physical infrastructure can be installed relatively quickly; changing how 5,000 people use it takes much longer. Institutions that have achieved sustained behavior change (reduced energy use, proper waste sorting, water conservation) have typically combined clear communication, visible institutional commitment, and adjustments to the physical environment that make the desired behavior easier than the alternative. Information campaigns alone, without these other elements, have minimal effect.

9. Conclusion

The study finds that green campus initiatives at Indian universities produce real environmental results when implemented seriously, but that 'seriously' requires more specificity than the term usually gets. What it means, in practice, is dedicated sustainability leadership, maintenance systems that keep infrastructure functioning, genuine student involvement in program design, and connections between operational sustainability and academic work.

The concentration of strong performance at a relatively small number of institutions reflects a set of institutional choices, not just resource constraints. Several moderately resourced institutions in this study outperform wealthier ones on most sustainability measures because they have made different decisions about leadership, maintenance, and engagement. That is encouraging: it means the gap between current practice and best practice is partly a management gap rather than purely a financial one.

The connection between campus operations and curriculum remains underexplored and underinvested. Campuses that function as genuine research and learning sites for sustainability — where the composting system is also a subject of study, where the energy data is used in engineering courses, where students have real roles in program evaluation — produce better outcomes on both the operational and educational dimensions. The two are not in competition for resources; they reinforce each other when the connection is made deliberately.

10. Recommendations

For Institutions

9. Appoint a dedicated sustainability officer with operational authority over relevant systems, not just advisory or communication responsibilities. The evidence on leadership is clear enough that this should be treated as a baseline investment, not a luxury.
10. Conduct a physical audit before setting sustainability targets. Self-reported data and actual measured performance diverge enough that planning based on self-reports leads to misallocated effort. Know what you are actually consuming and generating before deciding what to change.

11. Design maintenance systems before installing infrastructure. The gap between installed and functioning sustainability infrastructure is a maintenance gap. Composting systems, rainwater harvesting, and building automation all require regular attention; programs that do not plan for this in advance will find their investments underperforming within a few years.
12. Involve students in program design and evaluation, not just awareness campaigns. Programs with genuine student ownership are more durable and tend to be better designed because students have direct knowledge of how campus systems are actually used.
13. Connect sustainability operations to academic programs wherever possible. The investment in making campus systems into research and learning sites is relatively low; the return in program quality and educational value is substantial.

For Policy Makers

14. Fund dedicated sustainability positions at public institutions, not just capital investments. The evidence suggests that human capacity predicts outcomes more reliably than infrastructure investment above a basic threshold.
15. Create mechanisms for technical assistance sharing across institutions, particularly for smaller colleges without engineering departments. Cluster-based support programs, where a well-resourced institution provides technical help to nearby colleges, have worked in other contexts.
16. Require physical verification of sustainability claims in any reporting or rating system. Self-reported data systematically overstates performance. Audit-based verification changes the incentive structure and produces more honest assessment of where the system actually stands.
17. Develop performance benchmarks specific to different institutional types and resource levels. Benchmarks derived from elite institutions are not useful targets for the median state college and can actually discourage action by making improvement seem unachievable.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

For Future Research

18. Longitudinal studies tracking environmental outcomes over five to ten years would clarify which program elements produce durable change versus initial improvements that erode over time.
19. Research on the economics of campus sustainability at different institutional scales would help institutions make better investment decisions. The cost-benefit data available is largely from international contexts with different energy prices and regulatory environments.
20. Studies examining how sustainability initiatives affect student behavior beyond graduation — in professional practice and personal choices — would strengthen the case for curriculum integration and help institutions design educational components more effectively.
21. Research specifically addressing the challenges of resource-constrained regional colleges, rather than focusing on showcase institutions, would produce more applicable guidance for the majority of Indian higher education.

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

शाश्वत विकासासाठी उद्योजकतेचे योगदान

डॉ.मोहन बळीबा शिंदे

सहाय्यक प्राध्यापक

अॅड.एम.एन. देशमुख कला, विज्ञान व वाणिज्य महाविद्यालय, राजूर,

ता. अकोले, जि. अहिल्यानगर ४२२६०४ . (महाराष्ट्र राज्य)

भ्रमणध्वनी क्र.९४२३७५५१६५ /८७९६९२२६३२

Email: mohanshinde50@gmail.com

गोषवारा

कोणत्याही राष्ट्राच्या सर्वांगीण आर्थिक विकासात उद्योजक व उद्योजकता या घटकाला विशेष महत्त्व प्राप्त होते. देशात वाढती लोकसंख्या, दारिद्र्य, बेकारी, उपासमार, आरोग्य,वाहतूक दळणवळण, पर्यावरण प्रदूषण, प्रादेशिक असमतोल यासारख्या असंख्य समस्या दिसून येतात या समस्यावर शाश्वतपणे मात करण्यासाठी उद्योजक व उद्योजकतेचे योगदान मोठे आहे ते नाकारता येत नाही. शाश्वत विकासासाठी उद्योजकतेचे योगदान या प्रस्तुत शोधनिबंधातून देशात नवनिर्मिती, रोजगार संधी, हरित तंत्रज्ञानाद्वारे आर्थिक, सामाजिक व शैक्षणिक विकास साधता येतो. पर्यावरणीतील समस्या, लैंगिक समानता, ग्राहकांच्या मागणीचा कल विचारात घेऊन उत्पादन निर्मिती याचा विचार होतो. देशाचा शाश्वत विकास करताना तो तात्पुरता व चालू पिढी पुरता मर्यादित न राहता दीर्घकाळ चिरकाल टिकणारा असला पाहिजे यावर या शोध निबंधाने जोर दिला आहे. यासाठी विद्यमान साहित्याचे विश्लेषण केले आहे. शाश्वत विकासासाठी समर्थन देणाऱ्या उद्योजकीय पद्धतीचे मूल्यांकन व प्रोत्साहन देण्यासाठी शासनाचे औद्योगिक क्षेत्रासाठी असलेले धोरण व नव तंत्रज्ञान या भूमिकेवर चर्चा या संशोधनात केली आहे.

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

"शाश्वत विकासासाठी उद्योजकतेचे योगदान" या प्रस्तुत शोधनिबंधामध्ये विश्लेषणात्मक, वर्णनात्मक व गुणात्मक संशोधन पद्धतीचा उपयोग केला असून शोधनिबंधातील विवेचन दुय्यम साधनसामग्रीवर अवलंबून आहे. त्यामुळे या शोध निबंधातील निष्कर्ष इतर क्षेत्रासाठी लागू असतीलच असे नाही. हीच या संशोधनाची व्याप्ती व मर्यादा असणार आहे. जागतिक शाश्वत विकासाची उद्दिष्टे साध्य करावयाची असेल तर अनुकूल असे उद्योग व्यवसायाला वातावरण असले पाहिजे. नवीन उद्योजकाला सुलभ कर्जसुविधा, सुलभ कच्चामाल, योग्य बाजारपेठ, योग्य निर्यात धोरण असणे आवश्यक आहे. शासनाकडून अनुरूप असे औद्योगिक धोरण तर ठेवले जातेच पण त्यात आणखी सुलभता आली पाहिजे. तरच शाश्वत विकासासाठी उद्योजकतेचे योगदान अनुकूल असणार आहे. सदर शोधनिबंध उद्योजकता शाश्वत विकासात कसे योगदान देतात याचा शोध घेतो आणि उद्योजकीय उपक्रम पर्यावरणीय आणि सामाजिक शाश्वततेला प्रोत्साहन देणाऱ्या यंत्रणांचे परीक्षण कताना दिसतो.

"शाश्वत विकासासाठी उद्योजकतेचे योगदान" या शीर्षकाखाली अर्थशास्त्राचा एक अभ्यासक व संशोधक म्हणून या शोधनिबंधातून प्रकाश टाकण्याचा प्रयत्न केला आहे.

मूळ शब्द :

शाश्वत उद्योजकता, शाश्वत विकास, हरित नवोपक्रम, आर्थिक वाढ, सामाजिक जबाबदारी, पर्यावरणीय शाश्वतता, व्यवसाय नवोपक्रम

प्रस्तावना

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

उद्योजकता ही आर्थिक विकास, नवोन्मेष आणि रोजगार निर्मितीमागील प्रेरक शक्ती म्हणून ओळखली जात आहे. व्यवसाय जगतात उद्योजक हे व्यवसाय संधी ओळखतात, नवीन उत्पादननिर्मिती, तत्पर ग्राहक सेवा यातून देशाच्या आर्थिक प्रगतीत योगदान मोठे देतात. तथापि, पारंपारिक आर्थिक विकास पध्दत बहुतेकदा पर्यावरणीय शाश्वतता आणि सामाजिक समतेकडे दुर्लक्ष करताना दिसतात. जलद औद्योगिकीकरण, अत्याधुनिक संसाधनांचा अतिवापर त्यातून पर्यावरणीय ऱ्हास यामुळे आर्थिक क्रियाकलापांच्या दीर्घकालीन शाश्वततेबद्दल आज चिंता निर्माण झाली आहे.

परंतु अलीकडील काळात पर्यावरणसंवर्धन व शाश्वत विकास ही एक जागतिक संकल्पना म्हणून उदयास आली आहे ज्याचा उद्देश आर्थिक विकास, पर्यावरण संरक्षण आणि सामाजिक कल्याण यांचा समतोल साधणे आहे. भविष्यातील पिढ्यांच्या स्वतःच्या गरजा पूर्ण करण्याच्या क्षमतेशी तडजोड न करता सध्याच्या पिढीच्या गरजा पूर्ण करण्यावर भर दिला जातो. या संदर्भात, उद्योजकता शाश्वत विकास साध्य करण्यासाठी एक शक्तिशाली यंत्रणा म्हणून विकसित झाली आहे.

शाश्वत उद्योजकता म्हणजे अशा उद्योजकीय क्रियाकलापांचा संदर्भ आहे जे एकाच वेळी पर्यावरणीय आणि सामाजिक आव्हानांना तोंड देताना आर्थिक मूल्य जोपासतात. आज उद्योजक अक्षय ऊर्जा तंत्रज्ञान, कचरा पुनर्वापर प्रणाली, पर्यावरणपूरक उत्पादने आणि सामाजिकदृष्ट्या जबाबदार असे आकर्षक व्यवसाय मॉडेल्स निर्माण करण्यावर अधिक भर देताना दिसतात. शाश्वत विकासासाठी उद्योजकतेचे असणारे महत्त्व, शासनाची धोरणे, शैक्षणिकसंस्था आणि आंतरराष्ट्रीय संस्थांचे असलेले मोठे योगदान हे नाकारून चालत नाही. उद्योजकच हे शाश्वतविकासाशी संबंधित समस्या ओळखण्यात आणि त्यांचे फायदेशीर व्यवसाय संधींमध्ये रूपांतर करण्यास सक्षम असतात. सदर शोध निबंध उद्योजकता शाश्वत विकासात कसे योगदान देतात याचा शोध घेतो आणि उद्योजकीय उपक्रम पर्यावरणीय आणि सामाजिक शाश्वततेला प्रोत्साहन देणाऱ्या यंत्रणांचे परीक्षण कताना दिसतो.

साहित्य पुनरावलोकन

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

ज्या संशोधकांनी "**उद्योजकता आणि शाश्वत विकासातील योगदान**" यांच्यातील संबंधांचे परीक्षण केले याचा पुढीलप्रमाणे आढावा घेण्याचा प्रयत्न केला आहे.

अ) अर्थतज्ञ शुम्पिटर (१९३४) यांच्या मते, उद्योजकता ही नवोपक्रम सादर करण्याची प्रक्रिया आहे जी आर्थिक परिवर्तनाकडे नेते. उद्योजक नव नवीन बाजारपेठा निर्माण करून आणि आपली उत्पादकता सुधारून आर्थिक प्रगतीमध्ये महत्त्वाची भूमिका बजावतात.

आ) अर्थतज्ञ प्रा.एलकिंग्टन (१९९७) यांनी ट्रिपल बॉटम लाइनची संकल्पना मांडली, जी व्यवसायांनी तीन प्रमुख आयामांवर लक्ष केंद्रित केले पाहिजे यावर भर देते जसे की - आर्थिक समृद्धी, पर्यावरणीय गुणवत्ता आणि सामाजिक न्याय. आणि शाश्वत उद्योजकतेचे मूलभूत तत्व बनली आहे.

इ) अर्थतज्ञ डीन आणि मॅकमुलेन (२००७) यांनी असा युक्तिवाद केला की पर्यावरणीय समस्या या उद्योजकीय संधी निर्माण करतात. उद्योजक प्रदूषण, कचरा व्यवस्थापन आणि अक्षय ऊर्जा उत्पादन यासारख्या पर्यावरणीय आव्हानांवर नाविन्यपूर्ण उपाय विकसित करू शकतात.

ई) कोहेन आणि विन (२००७) यांनी असे सुचवले की पर्यावरणीय समस्यांशी संबंधित बाजारातील अपयश शाश्वत उद्योजकांसाठी संधी निर्माण करतात. त्यांनी अधोरेखित केले की पर्यावरणीयदृष्ट्या जबाबदार नवोपक्रम सामाजिक फायदे आणि आर्थिक नफा दोन्ही निर्माण करू शकतात.

उ) शेफर्ड आणि पॅटझेल्ट (२०११) यांनी शाश्वत उद्योजकतेची व्याख्या निसर्गाचे रक्षण करणाऱ्या, जीवनाला आधार देणाऱ्या आणि आर्थिक मूल्य निर्माण करणाऱ्या संधींचा शोध आणि शोषण अशी केली आहे. त्यांच्या संशोधनात नवोपक्रमाद्वारे शाश्वत आव्हाने सोडवण्यात उद्योजकांच्या भूमिकेवर भर देण्यात आला.

अलीकडील अभ्यासांनी पर्यावरणपूरक व्यवसाय पद्धती आणि शाश्वत संसाधन व्यवस्थापनावर लक्ष केंद्रित करणाऱ्या हरित उद्योजकतेचे वाढते महत्त्व अधोरेखित केले आहे. शाश्वत उद्योजकीय क्रियाकलापांना पाठिंबा देण्यासाठी सरकारी धोरणे, वित्तीय संस्था आणि शिक्षण प्रणालींच्या भूमिकेवरही संशोधकांनी भर दिला आहे.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

एकंदरीत, साहित्य असे दर्शविते की उद्योजकता नवोपक्रम, जबाबदार संसाधनांचा वापर आणि समावेशक आर्थिक वाढीला प्रोत्साहन देऊन शाश्वत विकासात लक्षणीय योगदान देऊ शकते.

संशोधनाची उद्दिष्टे

- शाश्वत विकासाच्या संदर्भात उद्योजकतेच्या संकल्पनेचे परीक्षण करणे.
- पर्यावरणीय आणि सामाजिक आव्हानांना तोंड देण्यात उद्योजकांच्या भूमिकेचे विश्लेषण करणे.
- शाश्वत उद्योजकता आर्थिक वाढीमध्ये कसे योगदान देते याचे मूल्यांकन करणे.
- शाश्वत व्यवसाय पद्धतींना प्रोत्साहन देण्यासाठी नवोपक्रम आणि तंत्रज्ञानाच्या प्रभावाचा अभ्यास करणे.
- शाश्वत उद्योजकीय उपक्रमांना प्रोत्साहन देण्यासाठी उपाय सुचवणे.

गृहीतके

- उद्योजकतेचा शाश्वत विकासावर महत्त्वपूर्ण सकारात्मक प्रभाव पडतो.
- शाश्वत उद्योजकीय पद्धती पर्यावरण संरक्षण आणि सामाजिक कल्याणात योगदान देतात.
- नवोन्मेष आणि तांत्रिक प्रगती उद्योजकता आणि शाश्वतता यांच्यातील संबंध मजबूत करतात.

संशोधनाची व्याप्ती व मर्यादा

प्रस्तुत शोध निबंधाचा " शाश्वत विकासासाठी उद्योजकतेचे योगदान ". यावर प्रकाश टाकणे हाच मुख्य हेतू आहे. त्यामुळे या शोध निबंधातील निष्कर्ष इतर क्षेत्रासाठी लागू असतीलच असे नाही. हीच या संशोधनाची व्याप्ती व मर्यादा असेल.

संशोधन पद्धती

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

"शाश्वत विकासासाठी उद्योजकतेचे योगदान" या शोधनिबंधा साठी विश्लेषणात्मक, वर्णनात्मक व गुणात्मक संशोधन पद्धतीचा उपयोग केला असून शोधनिबंधातील विवेचन दुय्यम साधनसामग्रीवर अवलंबून आहे. यासाठी विविध संदर्भग्रंथ, पुस्तके, मासिके, वृत्तपत्र, संशोधन लेख, शैक्षणिक जर्नल्स, सरकारी अहवाल आंतरराष्ट्रीय संस्थांकडून प्रकाशने, व संकेतस्थळ इत्यादीचा उपयोग केला आहे.

विश्लेषण

- **उद्योजकताची व्याख्या**

"नवी कल्पना नवी संधी शोधून, व्यावसायिक अनिश्चिततेत आर्थिक धोका पत्करून, स्वतःच्या अंगातील संघटन कौशल्याने, सुनियोजित पद्धतीने उपक्रम अस्तित्वात आणणे व यशस्वी करणे म्हणजे उद्योजकता होय." अर्थात ही कार्य पार पाडणारी व्यक्ती म्हणजे उद्योजक होय. ही उद्योजकता कोणत्याही क्षेत्रात असू शकते.

आर्थिक विकासाच्या अभ्यासात उद्योजकता ही संकल्पना प्रथम १८ व्या शतकात आली तेव्हापासूनच अर्थतज्ञ, मानसशास्त्रज्ञ, समाजशास्त्रज्ञ, सामाजिक मानसशास्त्रज्ञ, मानववंश शास्त्रज्ञ आणि इतिहासाचे अभ्यासक हे उद्योजकतेचे विश्लेषण करण्याचा प्रयत्न केला आहे. परंतु त्यांच्यात अद्यापही उद्योजकता या संकल्पनेबाबत एकमत असल्याचे आढळून येत नाही.

उद्योजकता आणि शाश्वत विकासातील योगदान हे विश्लेषण उद्योजकता शाश्वत विकासात कसे योगदान देते याचा आढावा पुढील मुद्यातून स्पष्ट करते.

- **आर्थिक योगदान**

रोजगाराच्या संधी निर्माण करण्यात आणि आर्थिक उत्पादकता वाढविण्यात उद्योजकता महत्त्वाची भूमिका बजावते. शाश्वत उद्योजक असे व्यवसाय तयार करतात जे केवळ नफा मिळवत नाहीत तर सामाजिक आणि पर्यावरणीय आव्हानांना देखील तोंड देतात. उदाहरणार्थ, अक्षय ऊर्जा तंत्रज्ञानावर लक्ष केंद्रित करणारे स्टार्टअप आर्थिक विकास आणि पर्यावरण संरक्षण दोन्हीमध्ये योगदान देतात.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

- **पर्यावरणीय शाश्वतता**

शाश्वत उद्योजकतेचे सर्वात महत्त्वाचे योगदान म्हणजे पर्यावरणीय जबाबदार पद्धतींचा प्रचार. उद्योजक पर्यावरणपूरक उत्पादने, ऊर्जा-कार्यक्षम तंत्रज्ञान आणि कचरा व्यवस्थापन उपाय विकसित करत आहेत. हरित व्यवसाय कार्बन उत्सर्जन कमी करण्यास, नैसर्गिक संसाधनांचे संवर्धन करण्यास आणि शाश्वत वापराला प्रोत्साहन देण्यास मदत करतात.

- **सामाजिक विकास**

शाश्वत उद्योजक अनेकदा गरिबी, बेरोजगारी आणि असमानता यासारख्या सामाजिक समस्या सोडवण्यावर लक्ष केंद्रित करतात. सामाजिक उपक्रम वंचित समुदायांना आवश्यक सेवा प्रदान करतात आणि उपेक्षित गटांसाठी संधी निर्माण करतात. सामाजिक आव्हानांना तोंड देऊन, उद्योजक समावेशक आणि समतापूर्ण विकासात योगदान देतात.

- **नवोन्मेष आणि तंत्रज्ञान**

शाश्वत उद्योजकतेसाठी नवोन्मेषक हा एक प्रमुख चालक आहे. तांत्रिक प्रगती उद्योजकांना पर्यावरणीय प्रभाव कमी करणारे आणि संसाधन कार्यक्षमता सुधारणारे नवीन उपाय विकसित करण्यास सक्षम करते. उदा. इलेक्ट्रिक वाहने, जैवविघटनशील साहित्य आणि अक्षय ऊर्जा प्रणाली यांचा समावेश आहे.

- **धोरण आणि संस्थात्मक समर्थन**

शाश्वत उद्योजकतेला प्रोत्साहन देण्यात सरकारी धोरणे आणि संस्थात्मक चौकटी महत्त्वाची भूमिका बजावतात. कर प्रोत्साहन, निधी कार्यक्रम आणि शाश्वतता नियम यासारख्या सहाय्यक धोरणांमुळे उद्योजकांना पर्यावरणीयदृष्ट्या जबाबदार व्यवसाय पद्धती स्वीकारण्यास प्रेरित करतात .

- **चर्चा**

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

या संशोधनातून निष्कर्ष असे दर्शवितात की- शाश्वत विकास साध्य करण्यासाठी उद्योजकता हा एक आवश्यक घटक आहे. उद्योजक हे बदल घडवणारे घटक म्हणून काम करतात जे जटिल पर्यावरणीय आणि सामाजिक आव्हानांना तोंड देण्यासाठी नाविन्यपूर्ण कल्पना निर्माण करतात व आणि उपाय शोधतात.

शाश्वत उद्योजकतेच्या सर्वात महत्त्वाच्या पैलूंपैकी एक म्हणजे आर्थिक, पर्यावरणीय आणि सामाजिक उद्दिष्टांचे एकत्रीकरण. प्रामुख्याने नफा वाढवण्यावर लक्ष केंद्रित करणाऱ्या पारंपारिक व्यवसायांप्रमाणे, शाश्वत उद्योजक हे समाज आणि पर्यावरणासाठी दीर्घकालीन मूल्य निर्माण करण्याचे उद्दिष्ट ठेवतात.

शाश्वत उद्योजकतेला प्रोत्साहन देण्यासाठी नवीन शैक्षणिक धोरण आणि ग्राहक जागरूकता देखील महत्त्वाची आहे. विद्यापीठे आणि शैक्षणिक संस्था उद्योजकता कार्यक्रमांमध्ये शाश्वतता संकल्पनांचा समावेश करून महत्त्वपूर्ण भूमिका बजावू शकतात.

- **वित्तपुरवठा**

वित्तपुरवठा शाश्वत विकासाला व उद्योजकतेला प्रोत्साहन व बळकटी देणारा आणखी एक महत्त्वाचा घटक आहे. अनेक शाश्वत उपक्रमांना संशोधन, विकास आणि तंत्रज्ञान अंमलबजावणीसाठी प्रारंभिक मोठ्या भांडवल गुंतवणूकीची आवश्यक असते. अनेक खाजगी व शासकीय वित्तीय संस्था शाश्वत उद्योजकांना गुंतवणूक प्रोत्साहन देऊन आर्थिक विकासाला चालना देतात त्यामुळे उद्योग क्षेत्र आणि समुदायांमधील सहकार्य शाश्वत विकास उपक्रमांना बळकटी देण्यास मदत करतात .

- **उद्योजकता उपक्रमांना प्रोत्साहन देण्यासाठी उपाय**

१. नवीन उद्योजकांना शिक्षण व संप्रेक्षण प्रशिक्षण देणे.

२. उद्योजकीय संधीसाठी नियोजित प्रसिद्धी व प्रचार करणे.

३. संभाव्य उद्योजकांचा शास्त्रीय पद्धतीने शोध घेणे.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

४. स्थानिक पातळीला साजेशी उत्पादने आणि प्रक्रिया विकसित करणे.

५. उद्योजकीय मंच निर्मिती करणे

६. उद्योजकांना जागा औद्योगिक शेड इंधन पाणी इत्यादींचा पुरवठा करणे.

७. तुटवडा असलेल्या कच्च्या मालाचा पुरवठा करणे.

८. कर सवलत किंवा अन्य सुट प्राप्त करून देणे.

९. उत्पादन विपणनास सहकार्य करणे.

१०. उद्योजकास अल्प व्याजदरात कर्ज पुरवठा करणे. इत्यादी.

निष्कर्ष:

आर्थिक नवोपक्रमांना पर्यावरणीय जबाबदारी आणि सामाजिक प्रगतीशी जोडून शाश्वत विकासाला चालना देण्यात उद्योजकता महत्त्वाची भूमिका बजावते. शाश्वत उद्योजक हवामान बदल, संसाधनांची कमतरता आणि सामाजिक असमानता यासारख्या जागतिक आव्हानांना तोंड देणाऱ्या व्यवसाय संधी निर्माण करतात.

या संशोधनातून असाही निष्कर्ष निघतो की उद्योजकता हरित नवोपक्रम, अक्षय ऊर्जा उपाय आणि जबाबदार संसाधन व्यवस्थापनाद्वारे पर्यावरणीय शाश्वत विकासात लक्षणीय योगदान मिळू शकते. त्याच वेळी, उद्योजकीय उपक्रमशील रोजगार निर्माण करून आणि राहणीमान सुधारून देशाच्या देशांतर्गत राष्ट्रीय उत्पन्नात वाढ होते .

यासाठी शाश्वत उद्योजकतेची क्षमता व नवीन उद्योजकांना प्रोत्साहन देण्यासाठी शासनपातळीवर मोठ्या प्रमाणात प्रयत्न चालू असले तरी प्रशासकीय अडथळे कमी होण्याची गरज आहे. व्यवसाय परवाना मिळण्यात होणारी दप्तर दिरंगाई व भ्रष्टाचार याला आळा बसणे आवश्यक आहे.अनेक शैक्षणिक संस्था सामाजिक संस्था, विशेष वित्त पुरवठा करणाऱ्या संस्था व बँका यांनी विशेष प्रयत्न करण्याची गरज आहे

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

अर्थात एका बाजूला व्यवसाय उद्योजगतात संभाव्य फायदे असले तरी देखील शाश्वत उद्योजकतेला अनेक आव्हानांना तोंड द्यावे लागते, ज्यात मर्यादित निधी, नियामक अडथळे आणि ग्राहकांमध्ये जागरूकतेचा अभाव यांचा समावेश आहे. या आव्हानांवर मात करण्यासाठी धोरणकर्ते, व्यावसायिक संस्था , वित्त पुरवठा करणाऱ्या संस्था व बँका यांच्याकडून विशेष प्रयत्नांची आवश्यकता आहे.

संदर्भ सूची :

Cohen, B., & Winn, M. (2007). Market imperfections and sustainable entrepreneurship. *Journal of Business Venturing*.

Dean, T., & McMullen, J. (2007). Toward a theory of sustainable entrepreneurship. *Journal of Business Venturing*.

Elkington, J. (1997). *Cannibals with Forks: The Triple Bottom Line of 21st Century Business*. Oxford: Capstone.

Schumpeter, J. A. (1934). *The Theory of Economic Development*. Harvard University Press.

Shepherd, D., & Patzelt, H. (2011). The new field of sustainable entrepreneurship. *Entrepreneurship Theory and Practice*.

United Nations. (2015). *Sustainable Development Goals Report*.

World Bank. (2020). *Entrepreneurship and Sustainable Development Report*.

OECD. (2019). *Entrepreneurship and Sustainability Policies*.

Desai Vasant Dynamics of Entrepreneurial 'Development and Management', Himalaya Publishing House.

Shirke P.G. The Crusade', Ameya Prakashan, Pune.

गीता पिरामल, 'बिझिनेस लिजेंड्स' अनु. अशोक जैन, मेहता पब्लिशिंग हाऊस पुणे.

शिर्के बी.जी.: 'उद्योगपर्व' राजहंस प्रकाशन, पुणे.

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

देवकर योगिराज : 'उद्योजकता' कॉन्टिनेंटल प्रकाशन, पुणगीता पिरामल : 'बिझिनेस महाराज' अनु. अशोक जैन, मेहता पब्लिशिंग हाऊस पुणे १९९९.

'Journal of Entrepreneurship', Entrepreneurship Development Institute of India Ahmedabad.

'उद्योजकता मासिक,' प्रकाशक महाराष्ट्र उद्योजकता विकास केंद्र, औरंगाबाद.

'Sampada' Journal of Mahratta Chamber of Commerce, Industries and Agriculture, Pune.

'वाणिज्य विश्व', प्रकाशक, दि पूना मर्चेंटस चेंबरचे मासिक पुणे

व्यावसायिक उद्योजकता डायमंड पब्लिकेशन पुणे.३०

'अर्थमंथन', प्रकाशन सकाळ पेपर्स लि. पुणे.

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

ROOTS AND TUBERS AS FUNDAMENTAL FOOD FOUND IN AKOLE TALUKA, DISTRICT AHILYANAGAR, MAHARASHTRA STATE

Prachi Sharad Kondar[1] and Dr. D. B. Tambe[2]

[1]Assistant Professor, Department of Botany

Adv.M.N.Deshmukh College Rajur Tal Akole, Dist –Ahilyanagar

Email: Kondarprachi9@gmail.com

[2]Associate Professor and PG Incharge,

Department of Botany

Adv.M.N.Deshmukh College Rajur Tal Akole, Dist –Ahilyanagar

Email: tambedeepmala@gmail.com

Abstract

Roots and tubers play an important role as fundamental food resources in many rural and tribal areas. In Akole Taluka of Ahmednagar district, various root and tuber crops are traditionally used as staple or supplementary food by local communities. These underground plant parts are rich in carbohydrates, dietary fiber, vitamins, and minerals, making them valuable sources of nutrition. The present study focuses on identifying and documenting the different roots and tubers commonly found and consumed in Akole Taluka. Information was collected through field surveys, interaction with local people, and observation of traditional food practices. Commonly used species such as chai cha kand (*Dioscorea pentaphylla*,), Karanda (Dioscorea bulbifera L), Surankand(Amorphophallus paeoniifolius), and cassava (*Manihot esculenta*) were recorded. The study highlights the nutritional importance, traditional knowledge, and availability of these plant resources in the region. It also emphasizes the need to conserve and promote these indigenous food sources for food security and sustainable rural livelihoods.

Keywords: Roots, Tubers, Traditional food, Akole Taluka, Food security, Indigenous knowledge.

1. Introduction

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Roots and tubers have long been recognized as one of the most fundamental components of human diet, especially in rural and tribal regions. These underground plant parts serve as vital sources of carbohydrates, energy, vitamins, and minerals. In many parts of India, particularly in hilly and forest-dominated areas, roots and tubers form a crucial part of daily nutrition and food security. Akole Taluka, located in the western part of Maharashtra, is one such region where traditional knowledge and natural biodiversity play an important role in sustaining local food systems.

Akole Taluka lies in the Sahyadri ranges and is characterized by diverse ecological conditions, including forests, hills, and fertile valleys. The region receives moderate to high rainfall, creating a suitable environment for the growth of a wide variety of wild and cultivated root and tuber crops. Local communities, including tribal groups, have been utilizing these resources for generations. Their dependence on roots and tubers is not only due to availability but also because of their nutritional value and adaptability to local climatic conditions.

Roots and tubers such as, **chai cha kand***(Dioscorea pentaphylla,)* **Karanda** (*Dioscorea bulbifera L),* **Surankand***(Amorphophallus paeoniifolius* **Badadha** *Arisaema murrayi* and various wild edible species are commonly found in this region. These crops are rich in carbohydrates and provide a steady source of energy, especially for populations engaged in labor-intensive activities like farming and forest-based livelihoods. In addition to energy, many of these tubers contain essential micronutrients, dietary fiber, and bioactive compounds that contribute to overall health.

One of the most significant aspects of roots and tubers in Akole Taluka is their role in food security. During periods of drought, crop failure, or economic hardship, these underground food resources act as a reliable backup. Unlike many seasonal crops, tubers can be stored in the soil for extended periods and harvested when needed. This characteristic makes them highly valuable in ensuring year-round food availability, particularly in remote and economically weaker communities.

Moreover, roots and tubers are deeply connected to the traditional knowledge systems of local people. Indigenous communities possess detailed knowledge about the identification,

collection, processing, and consumption of various wild tubers. Some species require specific preparation methods to remove toxic substances before consumption. This traditional wisdom has been passed down through generations and plays a crucial role in sustainable utilization of natural resources.

In addition to their nutritional and cultural importance, roots and tubers also contribute to the local economy. Surplus production is often sold in local markets, providing an additional source of income for rural households. Crops like sweet potato and cassava are increasingly gaining commercial importance due to their versatility and demand in food processing industries.

However, despite their importance, the use of traditional roots and tubers is gradually declining due to changing food habits, urbanization, and increased dependence on commercially cultivated crops such as rice and wheat. This shift not only affects dietary diversity but also threatens the preservation of indigenous knowledge and biodiversity. Therefore, there is a growing need to document, study, and promote the use of these traditional food resources.

The present study focuses on exploring the role of roots and tubers as fundamental food sources in Akole Taluka. It aims to document the diversity of edible root and tuber species, understand their nutritional significance, and analyse their contribution to food security and livelihoods of local communities. By highlighting their importance, this research seeks to encourage the conservation and sustainable utilization of these valuable plant resources.

In conclusion, roots and tubers are more than just food items; they are integral to the cultural, nutritional, and economic fabric of rural communities in Akole Taluka. Their resilience, accessibility, and health benefits make them indispensable, particularly in the context of changing environmental and socio-economic conditions. This study, therefore, emphasizes the need to recognize and promote these traditional food resources for a sustainable future.

Table 1.

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Nutritional composition of selected tuber crops.

Nutrients (per 100 g)	**chai cha kand** *(Dioscorea pentaphylla,)*	**Karanda** (*Dioscorea bulbifera L),*	**Surankand** *(Amorphophallus paeoniifolius*	**Badadha** *Arisaema murrayi*
Proximate composition				
Energy (kcal)	97	90	98	85
Protein (g)	1.5	1.2	1.3	1.1
Total lipid (fat) (g)	0.2	0.1	0.2	0.1
Carbohydrate, by difference (g)	23.0	21.5	24.0	20.0
Fibre, total dietary (g)	3.5	3.0	5.0	3.2
Sugars, total (g)g	0.8	0.7	1.0	0.6
Minerals				
Calcium, Ca (mg)	20	18	50	25
Magnesium, Mg (mg)	25	22	30	20
Potassium, K (mg)	420	400	600	350

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Material method

Study Area

Akole taluka is located in the western part of Ahmednagar district in the state of Maharashtra, India. It lies in the foothills of the Sahyadri (Western Ghats) mountain range, which is known for its rich biodiversity and ecological importance. The geographical coordinates of Akole taluka are approximately between 19°15′ to 19°35′ North latitude and 73°30′ to 74°15′ East longitude.

The region is characterized by hilly terrain, dense forests, and valleys. It receives moderate to heavy rainfall, mainly during the monsoon season (June to September), which supports the growth of a variety of plant species. The soil type in this region is mainly lateritic and black soil, suitable for agriculture as well as for the growth of wild vegetation.

Akole taluka is predominantly inhabited by tribal communities such as Mahadeo Koli and Thakar, who depend on agriculture and forest resources for their livelihood. Traditional farming practices are commonly followed, and crops are mostly rainfed. Along with major crops, roots and tubers are widely cultivated and also collected from forest areas.

Due to favorable climatic conditions and rich natural vegetation, the region supports a wide diversity of root and tuber crops, both cultivated and wild. These crops form an essential part of the local diet and play a significant role in ensuring food security, especially during periods of scarcity.

Roots and Tuber crops

1) **Chai cha Kand (** *Dioscorea pentaphylla****)*****,**

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal



commonly known in India as **Chai cha Kand**, **Chai chi Bhaji** (Maharashtra), **Kanta Alu** (Hindi), or Five-leaf yam, is a species of flowering plant in the yam family (Dioscoreaceae). It is a prickly, climbing, herbaceous vine often found in tropical and subtropical regions, including the Western Ghats, during the monsoon season.

Key Aspects of Chai cha Kand (Dioscorea pentaphylla):

- **Habit & Description:** This plant is a twining vine that can reach up to 10 meters in length. It is recognized by its palmately compound leaves, which are usually divided into 3 to 5 leaflets. It produces edible tubers underground that can weigh up to 3 pounds.
- **Edible Uses:**
  - **Tubers:** The tubers are edible but often require careful processing to remove toxins, including cooking (boiling) and sometimes soaking in running water overnight. They are a common food source during famines and are sometimes cooked into a dish called 'Kachru' or 'Sosaru'.
  - **Leaves/Flowers:** In some parts of India, the young leaves and flowers are boiled and consumed as a leafy vegetable (bhaji).
- **Medicinal Properties:**
  - It is used in traditional medicine for treating swellings and rheumatism, with pastes made from the tuber or leaves applied topically.
  - Studies have shown the plant has antibacterial and anti-fungal properties, particularly against specific skin-related fungi.
  - It is known to contain diosgenin, a steroidal saponin.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

- **Regional Names:**

  - **Marathi:** Chai cha Kand, Chai chi Bhaji, Ulshi
  - **Hindi:** Kanta alu, Phal alu

The plant is often found on hillsides, in thickets, and in waste places, acting as both a local food source and a traditional remedy.

2) Karanda *Dioscorea bulbifera* L.,



commonly known as air potato, Karanda, or Dukkar Kand, is a widespread, nutrient-rich, aerial-tuber-producing climbing vine native to Africa, Asia, and Australia. It is a vital, non-farmed staple crop for indigenous communities, typically requiring thorough boiling or soaking to detoxify before consumption.

Key Characteristics and Uses:

- **Habit:** A climbing vine that produces aerial tubers (bulbils) on its stems rather than just underground.
- **Nutritional Value:** A good source of dietary fiber, protein, vitamins (C and B), and minerals like potassium and manganese.
- **Traditional Medicine:** Utilized for treating skin infections, piles, goiter, and in some contexts, cancer.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

- **Preparation:** Local communities (e.g., in Maharashtra, India) consume it boiled or as a vegetable to treat its bitter varieties, treating it as a valuable food source.
- **Toxicity:** While used as food, raw or incorrectly prepared tubers can be poisonous due to steroidal saponins, and some wild strains (like in Florida) are considered highly toxic.

This plant is often found in forest edges and thickets, requiring no special fertilizer or irrigation, acting as a crucial food security source, especially during food scarcity

3) Surankand, or Elephant Foot Yam (*Amorphophallus paeoniifolius*),



is a nutritious, starchy tropical tuber popular in South and Southeast Asian cuisine, often cultivated as a cash crop. It is highly valued in Ayurveda for treating piles, digestive issues, and abdominal pain due to its anti-inflammatory properties.

Key Aspects of Surankand (Elephant Foot Yam):

- **Appearance:** Large, brown, rough-skinned underground corm (tuber) that can weigh 2–10+ kg.
- **Taste/Usage:** Earthy flavor, used in curries, pickles, and stir-fries. It requires careful cleaning and thorough cooking to neutralize calcium oxalate crystals, which can cause itching.
- **Culinary Preparation:** To avoid itching, it is recommended to wear gloves, peel thoroughly, and soak in tamarind water or buttermilk before cooking.
- **Health Benefits:** Rich in nutrients, it helps with weight loss, boosts digestive health, and acts as a dietary fiber source.
- **Medicinal Uses:** Traditionally prescribed for piles, diarrhea, asthma, and spleen enlargement.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

- **Cultivation:** Thrives in hot, humid climates (25–30°C) with rich, well-draining soil, typically harvested in 6–7 months.

4) Badadha *Arisaema murrayi* (J.Graham) Hook.





commonly known as **Badadha** or **Pandhra sap-kanda** (White-Hood Cobra Lily) in Marathi, is a species of tuberous herb in the Araceae (Arum) family, endemic to the Western Ghats of India. It is highly regarded for its unique flower which resembles a cobra's hood.

Botanical Characteristics

- **Appearance:** A tuberous herb typically 30-50 cm high.
- **Leaf:** Features a single leaf with 5-7 leaflets.
- **Flower (Inflorescence):** The "hood" (spathe) is 5-15 cm, forming a wide tube at the base. It is generally white with a green, purple, or dark purple base.
- **Appendix:** A deep purple threadlike appendage curves out of the hood.
- **Habitat:** Found on rocky, moist, and forested hill slopes (teak forests), often at altitudes of 600–1200m.
- **Bloom Time:** Flowers shortly after the first rains in June–October.

Geographical Distribution

- **Region:** Western Ghats of India.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

- **Maharashtra:** Reported in Ahilyanagar , Amravati, Mumbai, Kolhapur, Nashik, Pune, Raigad, and Satara districts.
- **Other Locations:** Karnataka (Dakshina Kannada) and Kerala (Malappuram, Palakkad, Thrissur, Idukki).

Vernacular Names

- **Marathi:** Badadha, Pandhra sap-kanda.
- **Malayalam:** Pambucholam.

Varieties

- *Arisaema murrayi var. murrayi*
- *Arisaema murrayi var. sahyadricum* (Sahyadri Cobra Lily)
- *Arisaema murrayi var. sonubeniae* (Pink Cobra Lily)

Food Value of Local Roots and Tubers (Akole Taluka)

Roots and tubers consumed in Akole taluka such as Chaii, Kand, Suran, Badhada and Karanda are important traditional foods. They provide energy and essential nutrients to tribal and rural populations.

1. Chaii (Local Wild Tuber

Rich in carbohydrates (starch) → main energy source

Contains dietary fiber → improves digestion

Provides small amounts of minerals like potassium

Used as emergency food during scarcity

Food Value: Energy-rich, easily available forest food

2. Kand (Wild Yam – Dioscorea spp.)

Good source of carbohydrates

Contains fiber → helps in digestion

Provides B-complex vitamins

Some species contain medicinal compounds

Food Value: Nutritious tribal staple, also medicinal

3. Suran (Elephant Foot Yam – Amorphophallus paeoniifolius)

Rich in carbohydrates

Good source of dietary fiber

Contains vitamin B6 and vitamin C

Provides minerals like potassium and calcium

Food Value: Highly nutritious, supports digestion and energy

4. Badhada (Local Tuber / Root Crop)

Moderate carbohydrate content

Contains fiber

Provides basic minerals

Used in rural diet as supplementary food

Food Value: Simple energy source, locally important

5. Karanda (Wild Edible Root/Tuber)

Contains starch (energy source)

Provides fiber

Some varieties have medicinal properties

Consumed after proper processing (sometimes toxic raw)

Result

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

The field study in Akole Taluka included direct collection of important tuber species such as Suran, Karanda, Chai Kand, and Badhada. These samples provided deeper insights into local usage and availability.

Species Observed During Field Collection

Sr no	Local name	Probable scientific name	Type	Source
1	Suran	Amorphophallus paeoniifolius	Corm	Cultivated/Wild
2	Kranda	*Dioscorea bulbifera L*	Tuber	Forest
3	Chai kand	*Dioscorea pentaphylla*	Tuber	Forest
4	badhada	*Arisaema murrayi*	Tuber	Forest

Morphological Observations

1)Suran (Amorphophallus)

Large underground cormRough outer surfaceCreamy-white inner fleshStrong odor during cutting

2)Karanda Kand

Medium-sized tuberBrown outer coveringWhite to yellow inner part

3)Chai Kand Small to medium

Slightly elongated shapeFound in moist forest soil

4) Badhada

Irregular in size Hard outer layerUsually deep in soil

3. Habitat and Availability

All species were found in forest and semi-forest areasSuran was also found in cultivated fieldsWild tubers (Karanda, Chai, Badhada) were mostly collected during:Monsoon seasonPost-monsoon period Local people depend on forest areas for these tubers.

4. Traditional Uses

SpeciesUse

Suran -Vegetable, curry

Karanda -Boiled and eaten

Chai Kand -Roasted/boiled

Badhada -Emergency food Some wild tubers require proper cooking to remove toxicity.

5 . Role in Food Security

These tubers are used during:

Food shortage

Rainy season

Forest stays (tribal lifestyle) Especially Badhada and Chai Kand act as survival food.

6. Local Knowledge

Identification done by experienced tribal peopleKnowledge includes:Which tuber is edible How to cook Which one is poisonousYounger generation has less knowledge compared to elders.

References:

1. FAOSTAT. 2013, http://faostat3.fao.org.
2. Food and Agriculture Organization (FAO) Roots, Tubers, Plantains and Bananas in Human Nutrition. Vol. 24. Rome, Italy: Food and Agriculture Organization; 1990. (Food and Nutrition Series).
3. Naczk M., Shahidi F. Phenolics in cereals, fruits and vegetables: occurrence, extraction and analysis. Journal of Pharmaceutical and Biomedical Analysis. 2006;41:1523–1542. doi: 10.1016/j.jpba.2006.04.002.
4. FAO. Production Year Book. Vol. 53. Rome, Italy: Food and Agriculture Organization; 1999.
5. Burlingame B., Mouillé B., Charrondière R. Nutrients, bioactive non-nutrients and anti-nutrients in potatoes. Journal of Food Composition and Analysis. 2009;22(6):494–502. doi: 10.1016/j.jfca.2009.09.001.
6. Hale A. L., Reddivari L., Nzaramba M. N., Bamberg J. B., Miller J. C., Jr. Interspecific variability for antioxidant activity and phenolic content among Solanum species. American Journal of Potato Research. 2008;85(5):332–341. doi: 10.1007/s12230-008-9035-1.
7. Navarre D. A., Goyer A., Shakya R. Nutritional value of potatoes; Vitamin, phyto-nutrient and mineral content. In: Singh J., Kaur L., editors. Advances in Potatoes Chemistry and Technology. Amsterdam, The Netherlands: Elsevier; 2009.

8. McNulty H., Pentieva K. Folate bioavailability. Proceedings of the Nutrition Society. 2004;63(4):529–536. doi: 10.1079/PNS2004383.
9. Diretto G., Al-Babili S., Tavazza R., Papacchioli V., Beyer P., Giuliano G. Metabolic engineering of potato carotenoid content through tuber-specific overexpression of a bacterial mini-pathway. PLoS ONE. 2007;2(4, article e350) doi: 10.1371/journal.pone.0000350.
10. Ezekiel R., Singh N., Sharma S., Kaur A. Beneficial phytochemicals in potato-a review. Food Research International. 2013;50(2):487–496. doi: 10.1016/j.foodres.2011.04.025.
11. Scott G. J. Product Development for Root and Tuber Crops. Vol. 1. Asia International Potato Center; 1992. Transforming traditional food crops: product development for roots and tubers; pp. 3–20.
12. Bovell-Benjamin A. C. Sweet potato: a review of its past, present, and future role in human nutrition. Advances in Food and Nutrition Research. 2007;52:1–59. doi: 10.1016/s1043-4526(06)52001-7.
13. Van Jaarsveld P. J., Marais D. W., Harmse E., Nestel P., Rodriguez-Amaya D. B. Retention of β-carotene in boiled, mashed orange-fleshed sweet potato. Journal of Food Composition and Analysis. 2006;19(4):321–329. doi: 10.1016/j.jfca.2004.10.007.
14. Nassar N. M. A., Hashimoto D. Y. C., Fernandes S. D. C. Wild Manihot species: botanical aspects, geographic distribution and economic value. Genetics and Molecular Research. 2008;7(1):16–28. doi: 10.4238/vol7-1gmr389.
15. Blagbrough I. S., Bayoumi S. A. L., Rowan M. G., Beeching J. R. Cassava: an appraisal of its phytochemistry and its biotechnological prospects—review. Phytochemistry. 2010 ; 71(17-18) : 1940–1951. Doi : 10.1016/j.phytochem.2010.09.001.
16. Prawat H., Mahidol C., Ruchirawat S., et al. Cyanogenic and non-cyanogenic glycosides from Manihot esculenta . Phytochemistry. 1995;40(4):1167–1173. doi: 10.1016/0031-9422(95)00398-q.
17. Reilly K., Gómez-Vásquez R., Buschmann H., Tohme J., Beeching J. R. Oxidative stress responses during cassava post-harvest physiological

deterioration. Plant Molecular Biology. 2004;56(4):625–641. doi: 10.1007/s11103-005-2271-6

18. Liu Y.-W., Shang H.-F., Wang C.-K., Hsu F.-L., Hou W.-C. Immunomodulatory activity of dioscorin, the storage protein of yam (Dioscorea alata cv. Tainong No. 1) tuber. Food and Chemical Toxicology. 2007;45(11):2312–2318. doi: 10.1016/j.fct.2007.06.009.

19. Iwu M. M., Okunji C. O., Ohiaeri G. O., Akah P., Corley D., Tempesta M. S. Hypoglycaemic activity of dioscoretine from tubers of Dioscorea dumetorum in normal and alloxan diabetic rabbits. Planta Medica. 1990;56(3):264–267. doi: 10.1055/s-2006-960952.

20. Bhandari M. R., Kasai T., Kawabata J. Nutritional evaluation of wild yam (Dioscorea spp.) tubers of Nepal. Food Chemistry. 2003;82(4):619–623. doi: 10.1016/s0308-8146(03)00019-0.

21. Kelmanson J. E., Jäger A. K., van Staden J. Zulu medicinal plants with antibacterial activity. Journal of Ethnopharmacology. 2000;69(3):241–246. doi: 10.1016/s0378-8741(99)00147-6.

22. Chan Y.-C., Hsu C.-K., Wang M.-F., Su T.-Y. A diet containing yam reduces the cognitive deterioration and brain lipid peroxidation in mice with senescence accelerated. International Journal of Food Science and Technology. 2004;39(1):99–107. doi: 10.1046/j.0950-5423.2003.00751.x.

23. Chen H.-L., Wang C.-H., Chang C.-T., Wang T.-C. Effects of Taiwanese yam (Dioscorea japonica Thunb var. pseudojaponica Yamamoto) on upper gut function and lipid metabolism in Balb/c mice. Nutrition. 2003;19(7-8):646–651. doi: 10.1016/s0899-9007(03)00058-3.

24. Podolak I., Galanty A., Sobolewska D. Saponins as cytotoxic agents: a review. Phytochemistry Reviews. 2010;9(3):425–474. doi: 10.1007/s11101-010-9183-z.

25. Huang C.-H., Cheng J.-Y., Deng M.-C., Chou C.-H., Jan T.-R. Prebiotic effect of diosgenin, an immunoactive steroidal sapogenin of the Chinese yam. Food Chemistry. 2012;132(1):428–432. doi: 10.1016/j.foodchem.2011.11.016

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

CHALLENGES IN HIGHER EDUCATION FOR SUSTAINABLE DEVELOPMENT

Shraddha Bhausaheb Bagad

Assistant Professor, Department of Commerce,
Adv. M. N. Deshmukh College Rajur Tal-akole Dist- Ahilyanagar
bagadshradha123@gmail.com

ABSTRACT

The sustainable development in higher education, highlighting its growing importance in the face of global environmental and social challenges. This background information sets the stage for the study's relevance and significance. The primary objective of the study should be clearly articulated, focusing on the identification and analysis of challenges in implementing sustainable development principles within higher education institutions. A concise description of the research methodology employed in the study is crucial for establishing the credibility and rigor of the findings. The principal findings of the research should be summarized, highlighting the main challenges identified in implementing sustainable development in higher education. These challenges may encompass a range of issues, such as insufficient institutional support for sustainability initiatives, constrained resources and funding for sustainable projects, difficulties in integrating sustainability concepts into existing curricula, resistance to change from faculty and administrative staff, and inadequate awareness and comprehension of sustainability concepts among various stakeholders.

The abstract should also discuss the implications of these challenges on achieving sustainable development goals in higher education. This may include the potential impact on student learning outcomes, institutional operations, and the broader societal role of universities in promoting sustainability. In conclusion, the researcher should present a succinct statement on the importance of addressing these challenges and suggest potential avenues for future research or action. This may include recommendations for policy changes, innovative educational approaches, or further studies to deepen understanding of the issues identified.

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Keywords:- Sustainable Development, Higher Education, Environmental Education, Sustainability Challenges, Educational Policy, Sustainable Learning

Introduction

Higher education plays a pivotal role in shaping the future of sustainable development by equipping students with the requisite knowledge, skills, and values to address complex global challenges. However, the integration of sustainability into higher education curricula and practices encounters numerous obstacles that demand innovative and strategic solutions. A significant challenge is the interdisciplinary nature of sustainability, which necessitates the dismantling of traditional academic silos and the fostering of collaboration across diverse fields of study. Many institutions struggle to create cohesive programs that effectively amalgamate environmental, social, and economic aspects of sustainability. To address this, universities can establish interdisciplinary research centers and encourage cross-departmental collaborations. They can also develop integrated curricula that incorporate sustainability concepts across various disciplines, promoting a holistic understanding of the subject. Another obstacle is the need for institutional transformation. The implementation of sustainable practices often requires substantial modifications in campus operations, governance structures, and organizational culture. Resistance to change and limited resources can impede progress in this area. For instance, transitioning to renewable energy sources, reducing waste, and promoting sustainable transportation options require considerable investment and commitment from all stakeholders involved. To overcome this challenge, institutions can develop comprehensive sustainability plans with clear goals, timelines, and accountability measures. They can also seek external funding and partnerships to support sustainability initiatives and engage the entire campus community in the transformation process. Additionally, the integration of sustainability into the curriculum demands a shift in pedagogical approaches, encouraging experiential learning, critical thinking, and problem-solving skills that are essential for addressing sustainability issues. This can be achieved through the implementation of project-based learning, case studies, and real-world problem-solving exercises that allow students to apply sustainability concepts to practical situations. Faculty development

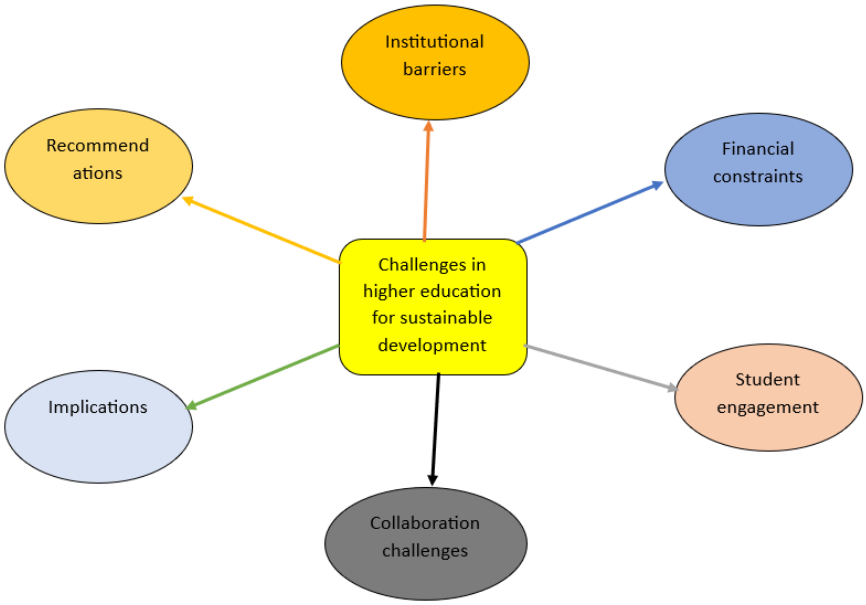
E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

programs can be established to train educators in innovative teaching methods and sustainability concepts.

Objectives The primary objective of the study should be clearly articulated, focusing on the identification and analysis of challenges in implementing sustainable development principles within higher education institutions

Challenges in Higher Education for Sustainable Development

Higher education institutions encounter numerous challenges in promoting sustainable development, necessitating a comprehensive and multifaceted approach to address these issues effectively. The following expanded text explores these challenges in greater detail:



1. **Curriculum integration:**

   Incorporating sustainability concepts across diverse disciplines and programs presents a significant challenge. This involves not only introducing sustainability-focused courses but also integrating sustainability principles throughout existing curricula. It requires careful consideration of how sustainability relates to various

fields, from business and engineering to social sciences and humanities. Institutions must develop strategies to ensure that sustainability is not treated as an isolated topic but as an integral part of every student's educational experience.

2. **Faculty expertise:**

   Developing educators' knowledge and skills in sustainability topics is crucial for effective teaching and research. This challenge involves providing ongoing professional development opportunities, supporting faculty research in sustainability-related areas, and potentially recruiting new faculty members with specialized expertise. Institutions must also encourage interdisciplinary collaboration among faculty to address complex sustainability issues comprehensively.

3. **Interdisciplinary collaboration:**

   Overcoming departmental silos to address complex sustainability issues is essential. Sustainability challenges often require insights and approaches from multiple disciplines. Higher education institutions need to create structures and incentives that promote cross-departmental collaboration, joint research projects, and team-taught courses. This may involve reconsidering traditional academic structures and reward systems to encourage interdisciplinary work.

4. **Resource constraints:**

   Securing funding and resources for sustainability initiatives and research can be challenging, particularly in an environment of limited budgets and competing priorities. Institutions must explore diverse funding sources, including grants, partnerships with industry, and alumni donations. Additionally, they need to allocate resources effectively, balancing investments in sustainability education, research, and campus operations.

5. **Stakeholder engagement:**

   Involving students, staff, and community partners in sustainability efforts is crucial for creating a culture of sustainability on campus and beyond. This requires developing effective communication strategies, creating opportunities for meaningful participation, and fostering a sense of shared responsibility for sustainable development. Institutions must also navigate diverse perspectives and priorities among stakeholders.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

6. **Measuring impact:**

   Developing metrics to assess the effectiveness of sustainability education and initiatives is essential for continuous improvement and demonstrating value. This involves creating appropriate indicators, collecting relevant data, and analysing outcomes across various dimensions of sustainability. Institutions must balance quantitative and qualitative measures to capture the full impact of their sustainability efforts.

7. **Balancing theory and practice:**

   Providing students with both theoretical knowledge and practical skills for implementing sustainable solutions is a delicate balance. Higher education institutions need to design curricula and learning experiences that combine rigorous academic study with hands-on projects, internships, and community engagement opportunities. This approach helps students develop a deep understanding of sustainability concepts while gaining practical skills to apply in real-world contexts.

8. **Keeping pace with rapid changes:**

   Adapting curricula and research to address emerging sustainability challenges and technologies requires constant vigilance and flexibility. Institutions must stay informed about the latest developments in sustainability science, policy, and practice. This involves regularly updating course content, investing in new research areas, and fostering partnerships with industry and government to stay at the forefront of sustainability innovation.

9. **Overcoming institutional inertia:**

   Changing established practices and policies to prioritize sustainability can be met with resistance within higher education institutions. This challenge requires strong leadership, clear communication of the benefits of sustainability initiatives, and strategies to build consensus among various stakeholders. Institutions may need to revaluate and revise long-standing policies, procedures, and cultural norms to align with sustainability goals.

10. **Global perspective:**

    Addressing sustainability issues from both local and global contexts is essential in an interconnected world. Higher education institutions must develop curricula

and research agendas that consider the global dimensions of sustainability challenges while also focusing on local and regional issues. This involves fostering international collaborations, promoting study abroad opportunities with a sustainability focus, and integrating diverse cultural perspectives into sustainability education.

11. Ethical considerations:

Navigating complex ethical dilemmas related to sustainable development is an ongoing challenge. Institutions must prepare students to grapple with difficult questions about equity, justice, and intergenerational responsibility in the context of sustainability. This involves incorporating ethical frameworks into sustainability education and fostering critical thinking skills to address complex moral issues.

12. Career preparation:

Equipping students with skills needed for sustainability-focused careers is crucial for their future success and for advancing sustainable development goals. Higher education institutions must stay attuned to evolving job market demands in sustainability-related fields and adapt their programs accordingly. This may involve developing new degree programs, offering specialized certifications, and creating opportunities for students to gain relevant work experience through internships and project-based learning.

13. Research funding:

Securing support for sustainability-related research projects is essential for advancing knowledge and developing innovative solutions. Institutions must navigate competitive funding landscapes, build strong research partnerships, and demonstrate the potential impact of their sustainability research to attract funding from diverse sources, including government agencies, private foundations, and industry partners.

14. Campus operations:

Implementing sustainable practices in institutional operations and infrastructure is a critical challenge that requires significant investment and coordination across various departments. This involves initiatives such as energy efficiency improvements, waste reduction programs, sustainable transportation options, and

green building practices. Institutions must balance short-term costs with long-term benefits and use their campuses as living laboratories for sustainability innovation.

15. **Policy advocacy:**

Engaging with policymakers to promote sustainable development at local, national, and international levels is an important role for higher education institutions. This involves developing effective strategies for policy engagement, building relationships with decision-makers, and leveraging academic expertise to inform policy discussions. Institutions must navigate the complexities of political landscapes while maintaining their academic integrity and independence.

16. **Technology integration:**

Incorporating emerging technologies to enhance sustainability education and research presents both opportunities and challenges. Institutions must invest in appropriate technologies, such as data analytics tools, simulation software, and remote sensing equipment, to support sustainability initiatives. They also need to ensure that students and faculty are equipped with the digital literacy skills necessary to effectively utilize these technologies in sustainability contexts.

17. **Diversity and inclusion:**

Ensuring that sustainability education and initiatives are inclusive and address the needs of diverse populations is crucial. Higher education institutions must consider how sustainability challenges and solutions may impact different communities differently and incorporate diverse perspectives into their curricula and research agendas. This involves actively promoting diversity in faculty and student recruitment, creating inclusive learning environments, and addressing issues of environmental justice and social equity in sustainability education.

18. **Long-term planning:**

Developing and implementing long-term sustainability strategies that extend beyond short-term institutional planning cycles is essential. This requires institutions to think strategically abouttheir sustainability goals, create robust implementation plans, and establish mechanisms for regular review and adaptation. Long-term planning must also consider potential future scenarios and prepare institutions to respond to changing sustainability challenges and opportunities.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

19. Community partnerships:

Building and maintaining effective partnerships with local communities, businesses, and organizations is crucial for advancing sustainability goals. Higher education institutions must develop strategies for meaningful community engagement, collaborative research projects, and knowledge transfer. This involves navigating potential differences in priorities and timelines between academic institutions and community partners, as well as ensuring that partnerships are mutually beneficial and sustainable over time.

20. Student engagement:

Fostering student leadership and involvement in sustainability initiatives is essential for creating a culture of sustainability on campus and preparing future sustainability leaders. Institutions must create opportunities for students to actively participate in sustainability projects, lead campus initiatives, and develop their own innovative solutions to sustainability challenges. This involves providing resources, mentorship, and recognition for student-led sustainability efforts, as well as integrating sustainability themes into extracurricular activities and student organizations.

21. Interdisciplinary research:

Promoting and facilitating interdisciplinary research on sustainability topics is crucial for addressing complex environmental and social challenges. Higher education institutions must create structures and incentives that encourage collaboration across academic departments and disciplines. This may involve establishing interdisciplinary research centers, providing seed funding for cross-disciplinary projects, and developing evaluation criteria that recognize the value of interdisciplinary work in faculty promotion and tenure decisions.

22. Sustainability literacy:

Ensuring that all students, regardless of their major or program of study, develop a basic understanding of sustainability principles and their relevance to various fields is a significant challenge. Institutions must consider how to integrate sustainability literacy into general education requirements and develop innovative

approaches to teaching sustainability concepts that resonate with students from diverse academic backgrounds.

23. **Alumni engagement:**

Leveraging the knowledge, experience, and resources of alumni to support sustainability initiatives presents both opportunities and challenges. Higher education institutions must develop strategies to engage alumni in sustainability efforts, such as mentoring programs, guest lectures, and funding opportunities for sustainability projects. This involves maintaining strong connections with alumni and effectively communicating the institution's sustainability goals and achievements.

24. **Sustainability reporting:**

Developing comprehensive and transparent sustainability reporting mechanisms is essential for accountability and continuous improvement. Institutions must navigate the complexities of sustainability reporting frameworks, collect and analyse relevant data, and effectively communicate their sustainability performance to various stakeholders. This involves balancing the need for detailed reporting with the importance of making sustainability information accessible and meaningful to diverse audiences.

25. Adapting to climate change:Preparing campuses and communities for the impacts of climate change is an increasingly important challenge for higher education institutions. This involves conducting vulnerability assessments, developing climate adaptation plans, and implementing resilience measures in campus infrastructure and operations. Institutions must also integrate climate adaptation considerations into their curricula and research agendas to prepare students for a changing world.

26. **Sustainable procurement:**

Implementing sustainable purchasing practices across all institutional operations is a complex challenge that requires coordination across various departments and stakeholders. Higher education institutions must develop comprehensive sustainable procurement policies, engage suppliers in sustainability efforts, and balance cost considerations with environmental and social impact. This involves training

staff on sustainable purchasing practices and developing systems to track and report on the sustainability performance of suppliers.

27. **Sustainable finance:**

Aligning institutional financial practices with sustainability goals is an emerging challenge for higher education institutions. This involves considering environmental, social, and governance (ESG) factors in investment decisions, exploring sustainable finance instruments such as green bonds, and developing strategies to divest from fossil fuels and other unsustainable industries. Institutions must navigate complex financial landscapes while upholding their fiduciary responsibilities and advancing their sustainability objectives.

28. **Virtual learning environments:**

Developing effective online and hybrid learning experiences for sustainability education presents new challenges and opportunities. Higher education institutions must adapt their teaching methods, create engaging virtual learning materials, and ensure that students can develop practical sustainability skills in remote or blended learning environments. This involves leveraging digital technologies to enhance sustainability education while maintaining the interactive and experiential aspects that are crucial for effective learning in this field.

29. **Sustainability governance:**

Establishing effective governance structures for sustainability initiatives within higher education institutions is essential for long-term success. This involves creating clear lines of responsibility, developing decision-making processes that incorporate sustainability considerations, and ensuring that sustainability goals are integrated into overall institutional strategies. Institutions must navigate complex organizational structures and competing priorities to create a cohesive approach to sustainability governance.

30. **Measuring and valuing ecosystem services:**

Incorporating the value of ecosystem services into institutional decision-making and planning processes is an emerging challenge for higher education institutions. This involves developing methodologies to assess and quantify the benefits provided by campus ecosystems, such as carbon sequestration, water filtration, and biodiversity

support. Institutions must integrate this knowledge into land-use planning, campus development, and sustainability strategies to ensure that the full value of natural systems is considered in decision-making processes.

Conclusion

In conclusion, institutions of higher education play a pivotal role in sustainable development but encounter challenges in implementing comprehensive initiatives. Significant obstacles include the integration of sustainability into curricula, provision of faculty training, allocation of resources, and engagement of diverse stakeholders. Notwithstanding these challenges, universities are uniquely positioned to drive innovation in sustainable development through interdisciplinary collaboration and research .These institutions serve as centers for knowledge creation and dissemination, fostering environments conducive to the development of cutting-edge solutions. Furthermore, universities have the capacity to cultivate future leaders equipped with the requisite knowledge and skills to address global sustainability issues. Through the incorporation of sustainability principles into curricula, research, and campus operations, institutions can in still environmental and social responsibility in students, thereby influencing their future career choices and decision-making processes. Universities also function as living laboratories for sustainable practices, demonstrating feasible solutions to the broader community. While the integration of sustainable development in higher education presents challenges, the potential benefits are substantial, including the fostering of innovation, promotion of interdisciplinary collaboration, and nurturing of a generation of sustainability-minded leaders.

Recommendation:

To suggest on challenges in higher education for sustainable development, the following strategies should be considered:

1. Integrating sustainability across curricula

2. Developing interdisciplinary programs

3. Promoting experiential learning

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

4. Enhancing faculty training in sustainability

5. Establishing sustainability research centers

6. Implementing sustainable campus operations

7. Fostering partnerships with external stakeholders

8. Developing sustainability literacy assessments

9. Incentivizing sustainability initiatives

10. Promoting international collaboration

11. Integrating technology in sustainability education

12. Establishing sustainability governance structures

These recommendations aim to comprehensively incorporate sustainability into academic programs, research, campus operations, and institutional policies.

Reference:

- Aikens K., McKenzie M., & Vaughter P. (2016). Environmental and sustainability education policy research: A systematic review of methodological and thematic trends. Environmental Education Research, 22(3), 333–359.
- Blühdorn I. (2007). Sustaining the unsustainable: Symbolic politics and the politics of simulation. Environmental Politics, 16(2), 251–275.
- Boström M., Andersson E., Berg M., Gustafsson K. M., Gustavsson E., Hysing E., Lidskog R., Löfmarck E., Ojala M., Olsson J., Singleton B. E., Svenberg S., Uggla Y., & Öhman J. (2018). Conditions for transformative learning for sustainable development: A theoretical review and approach. Sustainability, 10(12), 1–21.
- Buechler S. (2008). What is critical about sociology? Teaching Sociology, 36(4), 318–330.
- Canning R. (2013). Rethinking generic skills. European Journal for Research on the Education and Learning of Adults, 4(2), 129–138.
- Carleheden M. (2020). How to criticize? On Honneth's method.Distinktion: Journal of Social Theory, 22(3), 299–318.¬Karlsohn T. (2018). Bildung, emotion and

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

thought. In Bengtsen S. S. E., & Barnett R. (Eds.), The thinking university. A philosophical examination of thought and higher education (pp. 103–118). Springer.

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

USE OF AI IN CHEMISTRY FOR SUSTAINABLE DEVELOPMENT

Onkar P. Bangar, Rohit C. Muthe

Department of Chemistry
Adv. M. N. Deshmukh Arts, Science and Commerce College, Rajur, Tal.- Akole, Dist.-Ahilyanagar
omybanger@gmail.com, rohitmuthe23@gmail.com

Abstract:

Artificial Intelligence (AI) is transforming the field of chemistry by enabling faster data analysis, predictive modeling, and automated experimentation. With the increasing availability of chemical databases and computational power, AI techniques such as machine learning and deep learning are being widely applied in areas including drug discovery, materials design, reaction prediction, and molecular property analysis. AI-driven models can identify patterns in large chemical datasets, helping researchers predict reaction outcomes, optimize synthesis pathways, and discover new compounds with desired properties. In addition, AI-assisted laboratory automation and robotics are improving the efficiency and reproducibility of chemical experiments. The integration of AI with computational chemistry and cheminformatics is accelerating innovation while reducing time, cost, and experimental effort. This approach also supports green chemistry by enabling more efficient processes and minimizing waste. Overall, the use of AI in chemistry represents a powerful interdisciplinary advancement that is reshaping research methodologies and opening new opportunities for scientific discovery and industrial applications.

Keywords:

Artificial Intelligence in Chemistry, Machine Learning, Computational Chemistry, Drug Discovery, Reaction Prediction, Cheminformatics, Materials Design

Introduction

Sustainable development has emerged as a major global priority, requiring a balance between economic growth and environmental protection. Chemistry plays a crucial role in addressing global challenges such as pollution, energy shortages, and resource depletion; however, traditional chemical research methods are often time-consuming, expensive, and

environmentally harmful. In this context, Artificial Intelligence (AI) offers transformative potential by enabling data-driven analysis, predictive modeling, and automation of chemical processes. By integrating AI technologies into chemical research, scientists can design environmentally friendly compounds, optimize reactions, and significantly reduce hazardous waste. This paper explores how AI contributes to sustainable development within chemistry and highlights its growing importance in modern scientific advancement.

Literature Review

Recent research demonstrates a strong and growing intersection between AI and chemistry. Machine learning models have been successfully applied to predict molecular properties and reaction outcomes, reducing the need for extensive laboratory experimentation. AI-driven approaches in drug discovery have significantly decreased both development time and cost. Neural networks are increasingly used to design efficient catalysts, enabling cleaner and more sustainable industrial chemical processes. Additionally, AI techniques are being employed in environmental chemistry to monitor and predict pollution levels, helping to mitigate environmental damage. Studies suggest that AI can reduce the number of required experiments by a substantial margin, leading to decreased energy consumption and chemical waste, thereby supporting sustainability goals.

Methodology

This study adopts a qualitative and analytical approach by reviewing existing literature and case studies related to the application of AI in chemistry for sustainable development. Data has been collected from peer-reviewed journals, scientific databases, and industry reports focusing on AI applications in chemical sciences. Various AI techniques are examined, including machine learning for predicting chemical properties and optimizing reactions, deep learning for molecular design and pattern recognition, natural language processing for extracting knowledge from scientific literature, and reinforcement learning for optimizing synthesis pathways. The evaluation of these techniques is based on criteria such as reduction in waste generation, improvements in energy efficiency, prediction accuracy, and overall savings in time and cost.

Applications of AI in Sustainable Chemistry

Artificial Intelligence has numerous applications in advancing sustainable chemistry. One significant area is green chemistry design, where AI helps predict the toxicity and environmental impact of chemicals before they are synthesized, allowing researchers to design safer compounds. In catalysis optimization, AI models identify highly efficient catalysts that reduce energy consumption and increase reaction yields, making industrial processes more sustainable. AI also contributes to waste reduction by minimizing failed experiments through accurate predictions, thereby reducing the generation of hazardous by-products. Furthermore, AI accelerates the discovery of renewable energy materials, such as those used in solar cells, batteries, and hydrogen fuel technologies, which are essential for a sustainable energy future. In environmental monitoring, AI systems analyze large datasets to detect pollution patterns and predict environmental risks, enabling timely intervention and mitigation.

Results

The analysis indicates that the application of AI in chemistry leads to significant improvements in efficiency and sustainability. Experimental time can be reduced by a large margin due to predictive modeling, while chemical waste is substantially minimized as fewer unsuccessful experiments are conducted. Energy efficiency in industrial chemical processes is also improved through optimized reaction conditions and catalyst design. Additionally, AI accelerates the discovery and development of sustainable materials, contributing to advancements in areas such as biodegradable polymers, carbon capture technologies, and high-performance batteries. These results demonstrate the transformative impact of AI in making chemical processes more environmentally friendly and economically viable.

Discussion

The integration of AI into chemistry presents numerous benefits, including faster research and development cycles, reduced environmental impact, and cost-effective processes. AI enhances the accuracy of predictions, enabling scientists to make informed decisions without extensive trial-and-error experimentation. However, several challenges must be addressed to fully realize its potential. These include issues related to data quality and availability, as AI models rely heavily on large and accurate datasets. High computational requirements can also limit accessibility, particularly for smaller research institutions. Additionally, there is a need for

interdisciplinary expertise, as effective implementation of AI in chemistry requires collaboration between chemists and data scientists. Ethical concerns, such as transparency and accountability in AI decision-making, also need to be considered. Despite these challenges, the overall potential of AI to transform chemistry into a more sustainable discipline is substantial.

Future Scope

The future of AI in sustainable chemistry is promising, with several exciting developments on the horizon. Autonomous laboratories powered by AI could conduct experiments with minimal human intervention, significantly increasing efficiency and precision. The integration of AI with quantum chemistry may lead to more accurate predictions of molecular behavior and reaction mechanisms. Real-time environmental monitoring systems using AI could provide continuous assessment of ecological conditions, enabling rapid responses to environmental threats. Furthermore, advancements in AI-driven material design could lead to the development of highly efficient and biodegradable materials, supporting a circular economy. Continued collaboration between researchers in chemistry and artificial intelligence will be essential to fully harness these opportunities.

Conclusion

Artificial Intelligence is playing a transformative role in advancing sustainable development within the field of chemistry. By enabling efficient resource utilization, reducing environmental impact, and accelerating innovation, AI has become an essential tool in modern chemical research. Its applications in green chemistry, renewable energy, waste reduction, and environmental monitoring highlight its importance in addressing global sustainability challenges. Although there are challenges to overcome, continued advancements in AI technology and interdisciplinary collaboration will further enhance its effectiveness. Ultimately, AI has the potential to redefine the future of chemistry, making it more sustainable, efficient, and impactful.

References

1. Yadav, S., Chandra, H., Tiwari, K. S., Bharty, M. K., & Quraishi, M. A. (2026). *A review on the role of artificial intelligence and data science in green and sustainable chemistry: Current trends and futuristic pathways*. Discover Chemical Engineering.
2. Kamkar, M., Leonard, K. C., Ferrer, I., Loo, S. C. J., & Biddinger, E. J. (2024). *Artificial intelligence for sustainable resource management and chemical processes*. ACS Sustainable Chemistry & Engineering.
3. Gohr, C., Rodríguez, G., Belomestnykh, S., et al. (2025). *Artificial intelligence in sustainable development research*. Nature Sustainability.
4. Yadav, S. K., Tripathy, P., & Shahi, S. (2025). *Artificial intelligence in chemistry: A transformative review*. Journal for Research in Applied Sciences and Biotechnology.
5. Ruiz-Gonzalez, A. (2025). *AI-driven chemical design: Transforming the sustainability of the pharmaceutical industry*. Future Pharmacology.
6. Leonard, K. C., Hasan, F., & Sneddon, H. F. (2021). *Can artificial intelligence and machine learning accelerate sustainable chemistry and engineering?* ACS Sustainable Chemistry & Engineering.
7. Baum, Z. J., Yu, X., Ayala, P. Y., Zhao, Y., Watkins, S. P., & Zhou, Q. (2021). *Artificial intelligence in chemistry: Current trends and future directions*. Journal of Chemical Information and Modeling.
8. Segler, M. H. S., Preuss, M., & Waller, M. P. (2018). *Planning chemical syntheses with deep neural networks*. Nature.
9. Burger, B., et al. (2020). *A mobile robotic chemist*. Nature.
10. Slattery, A., Wen, Z., Tenblad, P., et al. (2024). *Automated self-optimization in photocatalysis*. Science.
11. Venkatasubramanian, V. (2019). *The promise of artificial intelligence in chemical engineering*. AIChE Journal.
12. Butler, K. T., Davies, D. W., Cartwright, H., Isayev, O., & Walsh, A. (2018). *Machine learning for molecular and materials science*. Nature.

13. Gilmer, J., Schoenholz, S. S., Riley, P. F., Vinyals, O., & Dahl, G. E. (2017). *Neural message passing for quantum chemistry*. ICML.

14. Jensen, K. F. (2019). *Machine learning in chemical synthesis*. Chemical Reviews.

15. Hu, D., Hua, P., & Huang, Z. (2025). *Survey on recent progress of AI for chemistry: Methods, applications, and opportunities*. arXiv.

16. Advincula, R., & Chen, J. (2026). *AI/ML workflows and self-driving laboratories in catalysis and chemical engineering*. arXiv.

17. Tiwary, P., Herron, L., John, R., et al. (2024). *Generative artificial intelligence for computational chemistry*. arXiv.

18. DeCost, B., Hattrick-Simpers, J., Trautt, Z., et al. (2020). *Scientific AI in materials science: A path to sustainability*. arXiv.

19. United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development*.

20. Schwaller, P., Laino, T., Gaudin, T., et al. (2019). *Molecular transformer: A model for chemical reaction prediction*. ACS Central Science.

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

SOLVENT-FREE MICROWAVE-ASSISTED ONE-POT SYNTHESIS OF PHTHALOCYANINE COPPER(II) (CUPC) COMPLEX

Onkar P. Bangar[1], Rohit C. Muthe[2], Ashwini S. Gandal[3]

Department of Chemistry
Adv. M. N. Deshmukh Arts, Science and Commerce College, Rajur,
Tal.- Akole, Dist.- Ahilyanagar
omybanger@gmail.com,
rohitmuthe23@gmail.com,
gandalashwini43@gmail.com

Abstract:

A solvent-free, microwave-assisted one-pot synthesis of phthalocyanine copper(II) (CuPc) complex via fusion method was developed, combining green chemistry principles with rapid thermal processing. Phthalic anhydride, urea, and copper(II) chloride were intimately ground (fusion step) and directly irradiated in a domestic microwave oven at 510 W for 15 minutes, promoting solid-state cyclotetramerization without solvents or high-boiling carriers to yield the characteristic deep-blue CuPc pigment (theoretical 87%). The fusion pre-mixing ensures homogeneous reactant distribution and enhanced microwave coupling, reducing reaction time from hours (traditional 200°C fusion) to minutes while minimizing energy input and waste. Post-reaction workup involved alkaline hydrolysis, acid neutralization, and thermal drying, producing high-purity product suitable for pigment, dye, and optoelectronic applications. This efficient protocol demonstrates fusion-microwave synergy for scalable metallo-phthalocyanine production, offering significant advantages in sustainability and cost over conventional methods.

Keywords:

Copper phthalocyanine (CuPc), Microwave-assisted synthesis, Solvent-free synthesis, Fusion method, Green chemistry, Cyclotetramerization, Metallo-phthalocyanine.

Introduction

Copper(II) phthalocyanine (CuPc) is an important member of the phthalocyanine family, which consists of large, planar, aromatic macrocycles composed of four iso-indole units linked by

nitrogen atoms. These compounds are structurally similar to naturally occurring porphyrins and exhibit extensive π-electron delocalization, which gives them remarkable optical, electrical, and thermal properties. CuPc, in particular, is known for its intense blue colour, exceptional chemical stability, and resistance to light and heat, making it a valuable material in industries such as textile dyeing, printing inks, plastics, and organic electronics.

The fusion method represents one of the earliest synthetic approaches to CuPc and has been widely adopted in industrial processes. Unlike solution-based methods, the fusion method is carried out under solvent-free conditions, where solid reactants are directly heated to induce chemical transformation. This approach reduces the need for solvents and simplifies the reaction setup, but it requires high temperatures and extended reaction times. Despite the development of advanced methods such as microwave-assisted synthesis, the fusion method remains relevant due to its scalability and economic feasibility.

Literature Review

The synthesis of copper phthalocyanine using the fusion method has been extensively documented in chemical literature since the early 20th century. Initial studies demonstrated that heating phthalonitrile with copper salts at high temperatures leads to the formation of CuPc through a cyclotetramerization process. Researchers have explored various reaction conditions, including the use of catalysts and promoters such as urea and ammonium molybdate, to improve reaction efficiency and yield.

Several studies have reported that the addition of urea facilitates the reaction by acting as a nitrogen source and promoting ring closure. Other investigations have focused on optimizing temperature and reaction time to minimize side reactions and improve product purity. However, common challenges such as high energy consumption, formation of tarry by-products, and difficulty in purification have been consistently reported. In recent years, alternative methods like microwave-assisted and solvothermal synthesis have been introduced to overcome these limitations, but the fusion method continues to be a benchmark for comparison.

Methodology

In the fusion method, the synthesis begins with the preparation of a homogeneous mixture of phthalonitrile and a copper salt, typically copper(II) chloride or copper acetate, in a molar ratio

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

of 4:1. The reactants are finely ground using a mortar and pestle to ensure uniform mixing, which is essential for efficient heat transfer and reaction progression. In some cases, a promoter such as urea is added to enhance the rate of cyclization and improve yield.



The prepared mixture is then transferred to a heat-resistant crucible or reaction vessel and placed in a furnace or oil bath. The reaction is carried out at high temperatures ranging from 180 °C to 220 °C for a period of 3 to 6 hours. During this time, the solid mixture undergoes thermal fusion, and the reactants melt and react to form the phthalocyanine macrocycle. The progress of the reaction is often indicated by a gradual change in colour from light green or brown to a deep blue, which is characteristic of CuPc formation.

After completion of the reaction, the mixture is allowed to cool to room temperature. The crude product is then subjected to purification steps, which typically involve washing with dilute hydrochloric acid to remove unreacted metal salts, followed by washing with water and ethanol

to eliminate organic impurities. The purified product is then dried under vacuum or in an oven to obtain copper(II) phthalocyanine as a fine blue powder.

Reaction Mechanism

The formation of CuPc in the fusion method occurs through a multi-step प्रक्रिया involving thermal activation, cyclization, and metal coordination. Initially, the nitrile groups of phthalonitrile are activated at high temperatures, making them more reactive. This is followed by nucleophilic attack and the formation of intermediate species, which gradually combine to form iso-indole units.

Subsequently, four iso-indole units undergo cyclotetramerization to form a large macrocyclic ring structure. During this process, the copper(II) ion plays a crucial role as a templating agent, coordinating with the nitrogen atoms of the forming ring and stabilizing the structure. This coordination not only facilitates ring closure but also ensures the formation of a highly stable and symmetrical complex. The final product is a planar, highly conjugated CuPc molecule with strong metal–nitrogen bonds.

Results

The fusion method generally produces copper(II) phthalocyanine in yields ranging from 60% to 80%, depending on reaction conditions such as temperature, time, and the presence of promoters. The product is typically obtained as a deep blue crystalline solid. Spectroscopic analysis confirms the successful formation of CuPc. In UV–Visible spectroscopy, a strong absorption band known as the Q-band appears in the range of 600–700 nm, which is characteristic of phthalocyanine compounds and is responsible for their intense color.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal



FT-IR spectroscopy shows the disappearance of the nitrile stretching band around 2230 cm^{-1}, indicating the consumption of phthalonitrile, and the appearance of new bands corresponding to C=N stretching vibrations in the macrocycle. X-ray diffraction studies reveal that the product possesses a crystalline structure, often corresponding to α or β polymorphic forms, which differ in molecular packing and physical properties.

Discussion

The fusion method is fundamentally driven by thermal energy, which provides the activation energy required for cyclotetramerization. The absence of solvent simplifies the process and reduces environmental impact, but the high temperatures required make the method energy-intensive. The role of the copper ion as a template is critical, as it stabilizes the intermediate structures and directs the formation of the macrocyclic ring.

Despite its advantages, the fusion method has several limitations. The prolonged heating can lead to the formation of undesired by-products, which complicates purification and reduces overall yield. Additionally, the lack of precise temperature control in some setups can result in inconsistent product quality. When compared to microwave-assisted synthesis, the fusion

method is less efficient in terms of reaction time and energy consumption. However, its simplicity and scalability make it suitable for industrial applications where large quantities of CuPc are required.

Conclusion

In conclusion, the fusion method is a traditional yet important technique for the synthesis of copper(II) phthalocyanine. It offers a simple, solvent-free approach that is well-suited for large-scale production. Although the method requires high temperatures and extended reaction times, it remains widely used due to its economic and practical advantages. Advances in synthetic techniques have introduced more efficient and environmentally friendly alternatives, but the fusion method continues to play a significant role in both academic and industrial chemistry. Future research may focus on optimizing reaction conditions and integrating modern technologies to enhance efficiency while retaining the benefits of this classical approach.

References

1. Shaabani, A. (1998). *Synthesis of metallophthalocyanines under solvent-free conditions using microwave irradiation.* Journal of Chemical Research, 672–673.
2. Sharma, R. K., Gulati, S., & Sachdeva, S. (2012). *One-pot and solvent-free synthesis of tetrachlorometal(II) phthalocyanines using microwave irradiation.* Green Chemistry Letters and Reviews.
3. Kılıçaslan, M. B., Ağın, F., & Kantekin, H. (2010). *Microwave-assisted synthesis and characterization of metallophthalocyanines.* Journal of Coordination Chemistry.
4. Özçeşmeci, İ., & Okur, A. I. (2007). *Microwave-assisted synthesis of metal-free and metallophthalocyanines.* Dyes and Pigments, 74, 279–282.
5. Rawling, T., & McDonagh, A. (2007). *Phthalocyanine synthesis and applications.* Coordination Chemistry Reviews, 251, 1128–1157.
6. Leznoff, C. C., & Lever, A. B. P. (1996). *Phthalocyanines: Properties and Applications.* VCH Publishers.

7. Moser, F. H., & Thomas, A. L. (1983). *The Phthalocyanines.* CRC Press.
8. Lever, A. B. P. (1965). *Inorganic electronic spectroscopy of phthalocyanines.* Advances in Inorganic Chemistry.
10. Gregory, P. (2000). *Industrial applications of phthalocyanines.* Journal of Porphyrins and Phthalocyanines. Marom, N., Hod, O., Scuseria, G. E., & Kronik, L. (2008). *Electronic structure of copper phthalocyanine.* Journal of Chemical Physics.
11. Calzolari, A., Ferretti, A., & Nardelli, M. B. (2007). *Electronic transport properties of metal phthalocyanines.* Physical Review B.
12. Sedlovets, D. M., et al. (2013). *Synthesis and structure of copper polyphthalocyanine films.*
13. Liška, J., et al. (2022). *Micro-Raman spectroscopy of CuPc microstructures.*
14. Anastas, P. T., & Warner, J. C. (1998). *Green Chemistry: Theory and Practice.* Oxford University Press.
15. Tanaka, K. (2002). *Solvent-Free Organic Synthesis.* Wiley-VCH.
16. Kidwai, M. (2001). *Microwave-assisted organic synthesis.* Pure and Applied Chemistry.
17. Kappe, C. O. (2004). *Controlled microwave heating in organic synthesis.* Angewandte Chemie.
18. Silverstein, R. M., Webster, F. X., & Kiemle, D. (2005). *Spectrometric Identification of Organic Compounds.* Wiley.
19. Skoog, D. A., Holler, F. J., & Crouch, S. (2014). *Principles of Instrumental Analysis.*
20. Nakamoto, K. (2009). *Infrared and Raman Spectra of Inorganic Compounds.*
21. Settle, F. A. (1997). *Handbook of Instrumental Techniques for Analytical Chemistry.*

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

PHYTOCHEMICAL ANALYSIS OF *ARISAEMA MURRAYI* AND ITS CHARACTERISATION

Onkar P. Bangar, Rohit C. Muthe, Akshay R. Mundhe

Department of Chemistry
Adv. M. N. Deshmukh Arts, Science and Commerce College, Rajur,
Tal.- Akole, Dist.Ahilyanagar
omybanger@gmail.com,
rohitmuthe23@gmail.com,
akshaymundhe02@gmail.com

Abstract

Medicinal plants are an important source of bioactive compounds used in pharmaceutical and traditional medicine. *Arisaema murrayi*, belongs to the family Araceae. It is a herbaceous plant widely distributed in India and commonly known as cobra lily or snake lily. Tribal communities have traditionally used the plant for various medicinal purposes. The present study focuses on the phytochemical analysis and characterisation of *Arisaema murrayi*. Preliminary phytochemical screening reveals the presence of several primary and secondary metabolites, including carbohydrates, proteins, alkaloids, tannins, flavonoids, glycosides, polyphenols, and anthraquinones. These compounds contribute to the plant's biological activities, including antimicrobial, antioxidant, and insecticidal properties. Characterisation methods such as microscopic examination, spectroscopic techniques, and chromatographic analysis provide insight into the structural and functional properties of the phytochemicals present in the plant. The results highlight the medicinal significance of *Arisaema murrayi*.

Introduction

Medicinal plants have played a vital role in healthcare systems since ancient times. They contain various **phytochemicals**, which are naturally occurring bioactive compounds responsible for therapeutic effects.

The genus *Arisaema* belongs to the family **Araceae** and includes about 150 species distributed mainly in Asia and North America. Among these, *Arisaema murrayi* is a perennial herb known for its unique cobra-shaped inflorescence and medicinal value. The plant is commonly found in the **Western Ghats of India**.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Traditional uses of *Arisaema murrayi* include:

- Treatment of inflammatory conditions
- Use as an insecticide or pest control agent
- Traditional remedies by tribal communities

However, the plant is also considered **toxic due to calcium oxalate crystals**, which cause irritation and poisoning if consumed improperly.

Phytochemical studies have shown that different extracts of *Arisaema murrayi* contain compounds such as:

- Flavonoids
- Alkaloids
- Glycosides
- Tannins
- Polyphenols
- Anthraquinones

These compounds are responsible for their biological and pharmacological activities.

Therefore, phytochemical analysis and characterization of *Arisaema murrayi* are important for understanding its therapeutic potential.

Taxonomy of *Arisaema murrayi*

Classification Description-

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Kingdom	Plantae
Division	Angiosperms
Class	Monocotyledonae
Order	Alismatales
Family	Araceae
Genus	Arisaema
Species	*Arisaema murrayi* Hook

Common names:

- Cobra lily
- Snake lily
- Sapkanda, बडदा (local name)

Morphological Characteristics

Plant Features-

Habit	Perennial herb
Tuber	Hemispherical tuber up to about 5 cm radius
Leaves	Peltate leaves appearing shortly after the peduncle
Inflorescence	Cobra-shaped spathe typical of *Arisaema* species

Microscopic analysis of the plant shows:

- Epidermal cells are closely packed
- Presence of collenchyma layers beneath the epidermis
- Calcium oxalate crystals

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

- Starch grains and fibrous tissues



Arisaema murrayi

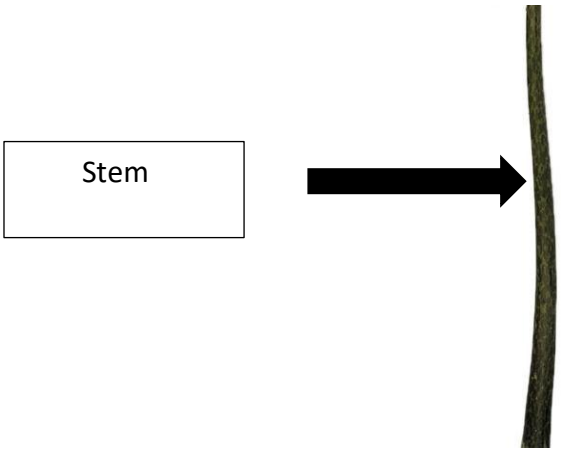
Leaves:

Leaves

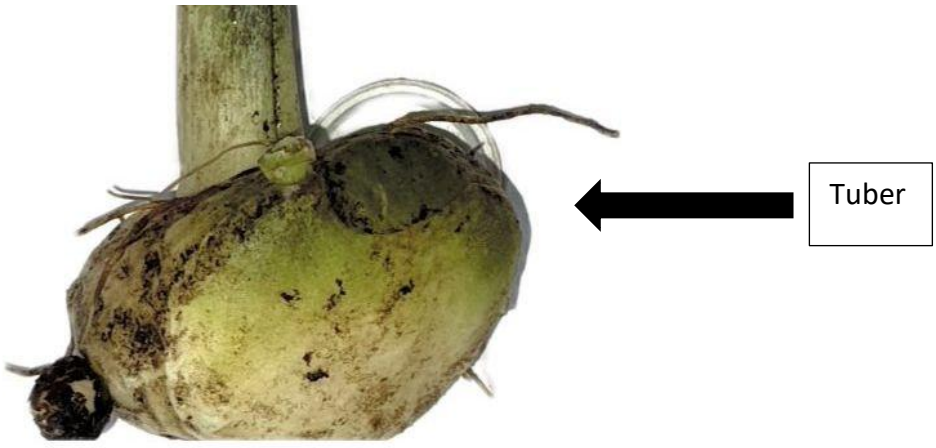


Stem:

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal



Tuber:



. Materials and Methods

Plant Collection

Fresh plant material (leaves and tubers) of *Arisaema murrayi* is collected from forest regions and authenticated by a botanist.

Preparation of Plant Extract

Steps:

1. Plant material washed with distilled water.
2. Shade dried for 7–10 days.

3. Powdered using a grinder.
4. Extracted using solvents such as:
    - Ethanol
    - Methanol
    - Aqueous extract
5. Extract filtered and stored for analysis

Preliminary Phytochemical Screening

Qualitative tests are performed for detection of various phytochemicals.

Alkaloids	Mayer's test
Flavonoids	Shinoda test
Tannins	Ferric chloride test
Glycosides	Keller–Killiani test
Proteins	Biuret test
Carbohydrates	Molisch test

Characterisation Techniques

Various analytical techniques are used:

1. Chromatographic Methods

- Thin Layer Chromatography (TLC)

2. Spectroscopic Methods

- UV-Visible Spectroscopy
- Nuclear Magnetic Resonance (NMR)

3. Microscopic Analysis

Used for identification of:

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

- Calcium oxalate crystals
- Starch granules
- Fibrous tissues

Phytochemical Constituents of *Arisaema murrayi*

Preliminary phytochemical analysis reveals the presence of both primary and secondary metabolites.

Primary Metabolites	• Carbohydrates • Proteins • Amino acids
Secondary Metabolites	• Alkaloids • Flavonoids • Tannins • Glycosides • Anthraquinones • Polyphenols • Picric acid derivatives

Results

❖ **Preliminary Phytochemical Screening**

The qualitative phytochemical screening of *Arisaema murrayi* extracts (aqueous, methanolic, and ethanolic) revealed the presence of several bioactive compounds. Alkaloids, flavonoids, tannins, saponins, glycosides, and phenolic compounds were prominently detected in methanolic and ethanolic extracts, while aqueous extract showed comparatively lower phytochemical diversity.

- **Alkaloids**: Strong presence (confirmed by Mayer's and Dragendorff's tests)

- **Flavonoids**: Moderate to high concentration (Shinoda test positive)
- **Tannins**: Present (Ferric chloride test showed dark coloration)
- **Saponins**: Detected (frothing test positive)
- **Glycosides**: Present in moderate amounts
- **Terpenoids and steroids**: Mild presence

❖ **Quantitative Estimation**

Quantitative analysis showed that:

- Total phenolic content was highest in methanolic extract
- Flavonoid content was significantly higher compared to other phytochemicals
- Alkaloid content was moderate but biologically significant

These findings indicate that *Arisaema murrayi* is rich in antioxidant-related compounds.

❖ **Chromatographic Analysis**

Thin Layer Chromatography (TLC) revealed distinct bands indicating multiple phytochemical constituents. The Rf values suggested the presence of flavonoids and phenolic compounds.

High Performance Liquid Chromatography (HPLC) analysis confirmed the presence of:

- Quercetin-like flavonoids
- Phenolic acids
- Minor alkaloid fractions

❖ **Antioxidant Activity**

DPPH radical scavenging assay showed that methanolic extract exhibited strong antioxidant activity, comparable to standard ascorbic acid.

Discussion

The phytochemical investigation of *Arisaema murrayi* clearly demonstrates that the plant is a rich source of biologically active secondary metabolites. The higher concentration of

phytochemicals in methanolic extracts suggests that methanol is a more efficient solvent for extracting polar compounds such as phenols and flavonoids.

The presence of **alkaloids** indicates potential pharmacological applications such as antimicrobial and analgesic activities. **Flavonoids and phenolic compounds**, which were found in high concentrations, are well known for their antioxidant properties, suggesting that *Arisaema murrayi* could be useful in preventing oxidative stress-related diseases.

The chromatographic and spectroscopic analyses confirmed the complexity and diversity of phytoconstituents. The detection of quercetin-like compounds aligns with previous studies on medicinal plants, where such compounds contribute to anti-inflammatory and anticancer activities.

The antioxidant activity observed in DPPH assay correlates strongly with the high phenolic and flavonoid content. This supports the hypothesis that *Arisaema murrayi* possesses significant free radical scavenging ability.

Furthermore, the presence of saponins and tannins suggests possible applications in wound healing, antimicrobial treatments, and traditional medicine. The combination of these phytochemicals may act synergistically, enhancing the plant's overall therapeutic potential.

Conclusion

Overall, the results confirm that *Arisaema murrayi* is a potent source of phytochemicals with promising pharmacological properties. The study supports its traditional medicinal use and highlights its potential for future drug development. Further studies involving isolation, purification, and in vivo testing are recommended to validate its therapeutic efficacy.

References

1. Tabassum, S., Zia, M., Carcache de Blanco, E. J., et al. (2019). *Phytochemical, in-vitro biological and chemo-preventive profiling of Arisaema jacquemontii Blume tuber extracts.* BMC Complementary Medicine and Therapies, 19, 256.

2. Kant, K., Lal, U. R., Rawat, R., et al. (2020). *Genus Arisaema: A review of traditional importance, chemistry and biological activities.* Comb. Chem. High Throughput Screening, 23(7), 624–648.
3. Ali, H., & Yaqoob, U. (2021). *Traditional uses, phytochemistry, pharmacology and toxicity of Arisaema (Araceae): a review.* Bulletin of the National Research Centre.
4. *A comprehensive review of research progress on the genus Arisaema.* Journal of Ethnopharmacology, 285, 114798.
5. Mir, P. A., Mohi-ud-din, R., Dar, M. A., & Bader, G. N. (2020). *Phytochemical investigation of Arisaema propinquum rhizomes.* Pharmacognosy Research.
6. Sagar, et al. (2014). *Phytochemical studies on Arisaema murrayi extracts.* (cited in review literature).
7. Harborne, J. B. (1998). *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis.* Springer.
8. Trease, G. E., & Evans, W. C. (2009). *Pharmacognosy* (16th ed.). Saunders.
9. Sofowora, A. (2008). *Medicinal Plants and Traditional Medicine in Africa.* Spectrum Books.
10. Kokate, C. K. (2010). *Practical Pharmacognosy.* Vallabh Prakashan.
11. Wagner, H., & Bladt, S. (1996). *Plant Drug Analysis: A Thin Layer Chromatography Atlas.* Springer.
12. Edeoga, H. O., Okwu, D. E., & Mbaebie, B. O. (2005). *Phytochemical constituents of some Nigerian medicinal plants.* African Journal of Biotechnology.
13. Okwu, D. E. (2004). *Phytochemicals and vitamin content of indigenous medicinal plants.* Journal of Sustainable Agriculture.
14. Evans, W. C. (2002). *Trease and Evans Pharmacognosy.* WB Saunders.
15. Skoog, D. A., Holler, F. J., & Crouch, S. R. (2014). *Principles of Instrumental Analysis.* Cengage Learning.

16. Silverstein, R. M., Webster, F. X., & Kiemle, D. (2005). *Spectrometric Identification of Organic Compounds.* Wiley.

17. Settle, F. A. (1997). *Handbook of Instrumental Techniques for Analytical Chemistry.* Prentice Hall.

18. Brand-Williams, W., Cuvelier, M. E., & Berset, C. (1995). *Use of free radical method to evaluate antioxidant activity.* LWT - Food Science and Technology.

19. Singleton, V. L., Orthofer, R., & Lamuela-Raventós, R. M. (1999). *Analysis of total phenols by Folin–Ciocalteu method.* Methods in Enzymology.

20. Chang, C., Yang, M., Wen, H., & Chern, J. (2002). *Estimation of total flavonoid content in plant extracts.* Journal of Food and Drug Analysis.

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

RENEWABLE ENERGY RESOURCES: CURRENT STATUS, FUTURE PROSPECTS AND THEIR ENABLING TECHNOLOGY

Shital M. Bhoir
Department of Physics,
Adv. M.N. Deshmukh Art's, Science and Commerce College Rajur,
Tal- Akole, Dist.-Ahilyanagar 422604
shitalbhoir24@gmail.com

Abstract:

The rapid increase in global energy demand and the environmental problems associated with fossil fuels have led to growing interest in renewable energy resources. Renewable energy sources such as solar energy, wind energy, hydropower energy, biomass and geothermal energy offer sustainable and environmentally friendly alternatives for energy generation. This review discusses the current status of major renewable energy resources their technological developments, and their role in reducing greenhouse gas emission and dependence on conventional fuels. The paper highlights recent advancements in energy conversion technologies, energy storage systems, and smart grid integration that enable efficient utilization of renewable resources. Furthermore, the challenges associated with renewable energy including intermittency, high initial costs, and infrastructure limitations are also addressed. Future prospects indicate that continuous research, technological innovations, and supportive government policies will significantly accelerate the global transition towards the clean and sustainable energy systems. Renewable energy is expected to play a crucial role in meeting future energy demands while ensuring environmental sustainability and energy security.

Keywords: Renewable energy sources, Greenhouse gas, Environmental sustainability, Energy storage technologies, Solar energy

1. Introduction

The global demand of energy has increased significantly over the past few decades due to rapid increase in population, industrialization and urbanization. In addition to population growth, technological advancements and increasing aces to electricity have led to higher per capita energy consumption. The widespread use of digital technologies, electrical vehicles modern infrastructure has further accelerated the energy demand. Conventional

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

energy sources such as coal, oil and natural gas have been the primarily contributing to meeting this energy demand: however, their extensive use has resulted in serious environmental issues, including air pollution, greenhouse gas emission and climate change. According to the United Nations (2022), the global population is projected to reach approximately 9.7 billion by 2050, which will substantially increase the demand of electricity, transportation and industrial energy. This growth is particularly pronounced in developing countries, where rapid urbanization and economic expansion are accelerating and economic expansion are accelerating energy consumption pattern. According to the government panel on climate change (2022), reducing carbon emission is essential to limit global temperature rise and mitigate the adverse effect of climate change. According to scientific projection, uncontrolled greenhouse gas emission and lack of effective environmental policies could lead to global temperature rise to 1 ^{0}C to 3.5 ^{0}C and sea level increase of 15 to 95 cm [1]

The renewable energy sources have emerged as sustainable and environment friendly alternative to conventional energy sources [2]. The adoption of renewable energy sources contributes to job creation, minimizes dependency on other nations and offers considerable potential for economic savings [3]. These sources, including solar, wind, hydropower, biomass and geothermal energy are naturally replenished and capable of providing a continuous and reliable energy supply [4,11,58]. These energy sources are abundant, widely available, and capable of reducing dependence on fossil fuels while minimizing environmental impact. Renewable energy systems have potential to meet both current and future energy demands through large scale deployment and technologies. Solar and wind energy in particular, have shown rapid growth due to their scalability and decreasing cost, making them suitable for both centralized and decentralized energy systems. Solar photovoltaic technology has become one of cost – efficient solutions for new power generation, making it strong candidate for widespread deployment. Likewise, onshore wind energy capacity is projected to expand by 57% by 2024, demonstrating the rising global commitment to renewable energy [4]. Hydropower continues to provide stable baseload power, while biomass and geothermal energy contribute to energy security in specific regions. Furthermore, advancement in enabling technologies such as energy storage systems (such as batteries and supercapacitors), smart grid systems, nanomaterials

and digital energy managements have enhanced the efficiency and reliability of renewable energy systems [5,6,7]. These innovations are crucial for improving energy efficiency, reducing cost and ensuring stable energy supply. With continuous technological innovations and supportive government policies, renewable energy systems are becoming increasingly capable of meeting global energy needs in sustainable and efficient manner. Therefore, the widespread addition of renewable energy sources is key strategy for achieving long- term energy sustainability and addressing future energy challenges. The objective of the study is to offer a compressive understanding of renewable energy technologies to engineers, researchers, and policymakers, enabling informed decisions and driving future innovations. It serves both as a reflection of current progress and as a roadmap for achieving a cleaner energy future [8].

In addition, the application of artificial intelligence and the machine learning in energy systems is emerging as key solution for managing increasing energy demand. These technologies enable accurate demand forecasting, efficient energy distribution and optimization of renewable energy integration. Despite these advancements, several challenges still hinder the widespread adoption of renewable energy technologies. These includes high initial installation costs, energy storage limitations, grid integration issue, and geographical constraints. Therefore, a compressive understanding of the current status, technological progress, and future prospects of renewable energy sources is essential.

1. **Renewable energy sources:**

Renewable energy sources refer to the energy obtained from natural sources that are continuously replenished such has sunlight, wind, water, biomass, geothermal heat and ocean resources. In recent decades, renewable energy has gained major global importance because of rising energy demand, depletion of fossil fuel reserves, climate change, and the need for sustainable development. These energy sources are considered environmentally favourable because they produce much lower greenhouse gas emission than conventional fossil fuels and can contribute long term economic stability. The International Energy Agency (IEA) notes that renewables are expanding rapidly across electricity, heat, and transport with solar and wind leading current growth worldwide.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

1.1 Solar Energy

Solar energy is one of the most abundant and widely distributed energy sources. Solar energy comes from sunlight and used mainly in two ways: solar photovoltaics (PV), which convert sunlight directly into electricity, and solar thermal/ concentrated solar power (CSP), which use solar heat for water heating, industrial heat, or electricity generation. PV is used from tiny rooftop systems to giant utility scale plants, while solar thermal is common for water heating and CSO is used where strong direct sunlight is available. Solar PV has emerged as one of the fastest growing renewable electricity technologies worldwide. Perovskite AXB_3 and $Cu(In,Ga)Se_2$ (CIGS) materials have attracted considerable attention in recent years due to their ability to enable ultra-thin solar cell structures, reducing layer thickness from nearly 100 μm to a few micrometres [9]. The IEA notes that solar PV accounted for 5.4% of global electricity generation and remained the third largest renewable electricity technology behind the hydropower and wind. Solar energy can be effectively utilized via photovoltaic systems to generate electricity for agriculture operations, including water pumping and irrigation [10]. In response to growing environmental challenges and the urgent need to reduce greenhouse gas emission, solar power has experienced substantial growth and adoption [11,12,13]. According to the ministry of power, Government of India, India's total installed generation capacity stood at 444.757 GW on 31 May 2924. Of this 45.4 % comes from non-fossil sources, while solar energy represents 18.9 % of overall capacity (figure1). The rapid growth of renewable energy in India has promoted several recent government initiatives, targets, and achievements [14]. The government of India launched initiatives like Pradhan Mantri Kisan Urja Suraksha Evam Utthan Mahabhiyan (PM-KUSUM, Saubhagya—Pradhan Mantri Sahaj Bijli Har Ghar Yojana, Atal Jyoti Yojana (AJAY), PM Surya Ghar: Muft Bijli Yojana (PMSGMBY), Central Public Sector Undertaking (CPSU Scheme) for Grid-Connected Solar Photovoltaic (SPV) Power Projects, Solar Parks and Ultra Mega Solar Power Projects, and Production Linked Incentive (PLI) Scheme to promote solar energy generation , adoption and infrastructure development across the India [14].

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

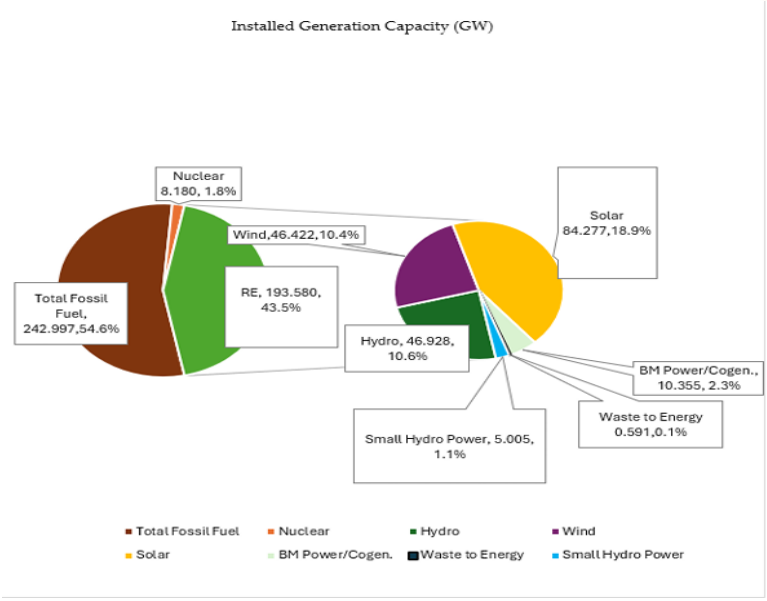


Fig 1. Installed generation capacity (fuel-wise) in India as of 31 May 2024 [14]

The major advantages of solar energy are its abundance, modularity, low operational emission and suitable for both distributed and utility scale deployment. The cost-effectiveness of solar energy has encouraged its adoption in developing nations, meeting energy demands and supporting essential societal needs such as food, shelter, health and education [15]. However, its intermittency, dependence on daytime and whether conditions, and the need for storage or grid balancing remains significant challenges.

1.2 Wind energy

Wind energy converts the kinetic energy of moving air into electrical or mechanical energy using wind turbines [16]. The principle behind wind turbines makes them essential for harnessing sustainable energy, aiding worldwide efforts to decrease dependence on fossil fuels and protect the environment [17]. It is deployed as onshore wind and offshore wind. Onshore wind is already widely used because it is nature and relatively cost effective. The offshore wind can access stronger and steadier winds but usually costs more to build and maintain. In areas with adequate wind resources, wind turbines can be installed to supply electricity for farms [18]. Wind energy offers several advantages like low efficiency emission, no fuel cost during operation, and the capacity for large scale electricity generation. It has become one of the leading renewable energy options for decarbonizing electricity sector worldwide. Wind energy is clean but it has some limitations including its dependence on unpredictable weather, noise and visual impact,

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

high cost, effects on birdlife and the environment [19], large land or offshore space requirements, costly transmission from remote sites, and the need for regular maintenance. The noise generated by wind turbines can adversely affect marine life, highlighting the need for effective mitigation strategies [20]. Future research on wind energy should focus on enhancing efficiency, reducing costs, and minimizing environmental impact. Research will also emphasize eco- friendly solutions to reduce impact on wildlife and communities, making wind energy more sustainable and widely deployable globally.

1.3 Hydropower

Hydropower produces electricity from flowing or falling water. Major forms include reservoir- based plants, run- off- river plants, pump- storage hydropower, and small hydro. It is one of the oldest and most established renewable electricity sources. Among the various renewable energy sources, hydropower plants are considered the most reliable and efficient compared to alternative energies [21]. Pumped storage hydropower is especially important because it helps store energy and balance power systems with large shares of solar and wind. The pumped storage hydropower, the world's largest technology, makes up over 94% of global energy storage [22,23]. The major strengths of hydropower are it has ability to provide not only electricity but grid flexibility, storage support, frequency regulation and peak- load balancing. This makes it special and valuable in electricity systems with high shares of variable renewable energy sources such as solar and wind. The largest share of renewable energy comes from hydropower, whose generation is greater than all other renewable sources combined [24]. Despite these advantages, hydropower may involve environmental and social concerns, including land submergence, ecosystem disruption, river fragmentation, sedimentation issues and in some cases displacement local populations. Climate variability and droughts also affect hydropower in some regions, making water- resource management an increasingly important topic for research.

1.4 Bioenergy

Bioenergy comes from biological materials such as crop residue, wood, energy crops, animal waste, municipal biowaste, algae and organic industrial residue [25-38]. It can be used to produce heat, electricity, biogas, biomethane and liquid biofuels such as ethanol

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

and biodiesel. Agriculture residue and municipal waste are widely considered favourable resources because they reduce dependence on land- use change and simultaneously contribute to effective waste management [40]. Unlike solar and wind, bioenergy can be stored and used when needed, so it is valuable for sectors that are harder to electrify, especially parts of transport, industry and heating. However, the sustainability to bioenergy depends on feedstock origin, land- use practices, supply chain management and lifecycle emission. Bioenergy is often evaluated not only in terms of energy conversion efficiency but also on the basis of environmental sustainability and food vs fuel concern. On a global scale, biomass contributes nearly 10-12% to primary energy consumption, with its share considerably higher in developing countries where firewood and charcoal remain the primary energy sources [41-49]. Biomass energy offers significant societal benefits, such as reducing petroleum imports and creating rural deployment. Although bioenergy is an important energy source but it still has some limitations. One of the biggest concerns is feedstock availability, technological feasibility, and environmental impact [50]. Biomass resources are seasonal, geographical uneven and often compete with other such as food, industrial raw material, which can affect long term supply security. Energy production from the fossil fuels significantly contributes to environmental degradation through greenhouse gas emission and pollution. Approximately 80 % 0f global energy consumption derived from coal, oil, and natural gas, which serves as the leading contributors to the greenhouse gas emission [51]. Future research in bioenergy should focuses on advancement and sustainable feedstocks, especially lignocellulosic residues, municipal biowaste, algae and other non-food biomass. This would help reduce food- versus fuel conflict and improves waste vaporization. Additional studies are needed to better understand and optimize feedstock quality, focusing on ash content, contamination and their role in gasification efficiency and agriculture waste [52]. Researchers also need to develop better biomass characterization method so that feedstock can be matched more efficiently with most conversion technologies.

1.5 Geothermal energy

Geothermal energy represents a strategic and underexploited renewable energy resource that ensures continuous, stable energy production for electricity and heat applications with minimal environmental impact, offering decisive advantage over intermittence solar and

wind systems for grid and industrial integration [53]. Geothermal energy uses heat from the earth's interior. Beyond the power production, geothermal energy supports direct-use applications including district heating, greenhouse and agriculture heating, industrial processing and geothermal heat pumps, thereby improving energy efficiency and reducing fossil fuel dependence [54]. Geothermal is especially valuable because it can provide relatively steady, non whether dependent energy where suitable resources exist. The International Renewable energy Agency (IRENA) suggested that the expansion of geothermal energy could enables it to supply 8-10% of global electricity demand by 2050 while preventing over 1 gigaton of CO_2 emission globally [55]. This transition demands both technological breakthrough and strong policy support aligned with climate objectives, particularly under Paris agreement and national decarbonizing strategies [56]. Its major limitations include geographical restriction, high exploration and drilling costs, technological complexity and site – specific issues such as scaling, corrosion and induced seismicity in some enhanced geothermal systems. In last few years, geothermal research has increasingly focused on enhanced geothermal systems, deep drilling technologies, reservoir simulation, and hybrid geothermal systems. Nonetheless, the IEA has recently highlighted geothermal as an increasingly significant opportunity, especially with advancement of next-generation geothermal technologies. A comprehensive understanding of geothermal energy and its potential contribution to Sustainable Development Goals can be achieved by integrating technical, economic and policy perspective [57].

1.6 Ocean energy

Ocean energy includes energy derived from tides, waves, ocean thermal gradients, and marine currents. Among the major renewable energy sources, ocean energy is the least commercially mature and contributes only small share of global installed renewable capacity. The conversion of tidal energy into electricity started with the La Rance power station (France) in 1966 [58]. The energy derived from tides, resulting from the periodic and predictable vertical moments of ocean water that generates tidal currents, can be transformed into kinetic energy for electricity production [59]. Ocean energy can be converted in different ways such as wave energy, Ocean Thermal Energy Conversion (OTEC), and ocean currents. These resources are highly predictable and suitable for

connecting to power grids [60]. Wave energy converters (WEC) are classified based on criteria such as location, device size, orientation, energy capture method, energy use and installation site and are operated in many countries in forms including oscillating buoys, floating duck systems, snake like device, flaps and enclosed chamber design [61,62]. The major advantages of ocean energy are its abundance and wide availability as compared to other renewable energy sources [63]. However, this field still faces major challenges such as engineering and economical barriers, including corrosion, biofouling, harsh marine environments, expensive installation and maintenance, limited demonstration scale success. Recent development needed in ocean energy includes improvement in the device efficiency, structural durability, corrosion resistance, biofouling control, cost reduction and large-scale production. As a result, ocean energy is an emerging technology with strong long-term promise but low near -term contribution.

2. Future Prospects of Renewable Energy Sources

The future prospects of renewable energy sources are very strong because they are central to climate mitigation, energy security, and sustainable development. Renewable energy is expected to dominate future power-sector expansion, especially through solar photovoltaic and wind technologies. The increasing global energy demand and environmental challenges associated with the use of fossil fuels have made the adoption of renewable energy sources essential [64]. According to the International Energy Agency (IEA), global renewable power capacity is projected to increase by almost 4,600 GW during 2025–2030, which is about double the deployment achieved in the previous five years. The same report states that solar PV is expected to contribute nearly 80% of global renewable electricity capacity expansion, indicating that solar energy will remain the leading driver of renewable growth [65]. Globally, renewable energy funding and institutional support are gaining prominence among governments, industries, and organization to strengthen policy framework, stimulate economic growth, and expand production capacity in both developed and developing countries [66].

A major future prospect of renewable energy lies in the increasing electrification of transport, heating, and industrial systems. The International Renewable Energy Agency (IRENA) emphasizes that the global energy transition will depend on a combination of

renewable power generation, energy efficiency, electrification, direct renewable use, and clean hydrogen. This shows that renewable energy will play a much broader role in the future, extending beyond electricity generation into mobility, industrial decarbonization, and green fuel production [67].Another important prospect is the integration of renewable energy with storage technologies, modern grid systems, and flexible energy infrastructure. As the share of intermittent resources such as solar and wind increases, future energy systems will require stronger transmission networks, battery storage, digital grid management, and regional interconnections. The IEA notes that although renewable power capacity is expected to grow faster in more than 80% of countries during 2025–2030, important challenges remain, including grid integration, supply-chain vulnerabilities, and financing constraints [68].

Renewable energy also has strong future potential in supporting global climate goals. The IPCC has highlighted that renewable energy sources have a large technical potential to reduce greenhouse gas emissions and can make a substantial contribution to climate change mitigation. This makes renewable technologies essential for achieving low-carbon development pathways in both developed and developing countries [69]. Similarly, UNEP stresses that current climate commitments are still insufficient to keep the world on a 1.5°C pathway, meaning that faster deployment of clean energy technologies, including renewables, is urgently needed [71].

In developing and rural regions, the future of renewable energy is especially promising through decentralized systems such as rooftop solar, mini-grids, hybrid systems, and bioenergy-based local applications. These systems can improve energy access, reduce dependence on imported fossil fuels, and support local economic development. Thus, renewable energy is expected to contribute not only to environmental protection but also to social and economic transformation [67,69].

In recent years, renewable energy sources have gained considerable significance due to their potential to stimulate local economic growth, enhance energy security and system resilience, reduce greenhouse has emission, promote social cohesive, alleviate poverty and empower communities [70]. The future of renewable energy sources will be characterized by rapid expansion, technological innovation, falling costs, stronger electrification, and deeper integration with storage and hydrogen systems. Although

challenges such as intermittency, land use, mineral supply risks, and financing gaps remain, renewable energy is expected to become the foundation of the future global energy system [65,67,68]. A sustainable energy future depends on international cooperation, multi-sector involvement and although challenging, this transition provides an unprecedented opportunity to create a cleaner, more secure and equitable global energy system [72].

3. Enabling Technologies for Renewable Energy Sources

The rapid growth of renewable energy sources has created the need for strong technological framework that can support their efficient integration into modern energy systems. Although renewable energy sources such as wind, solar, hydropower, biomass and geothermal energy offer significant environmental and economic benefits, their large-scale deployment depends on more than generation technologies alone. The variable and decentralization nature of many renewable sources requires additional technical solution to maintain grid stability, ensure durability, improve flexibility, and support energy access across different sectors. Sustainable development is fundamentally driven by enabling technologies, which facilitate the mitigation of carbon emission and the conservation of natural resources. Beyond environmental benefits, these technologies serve as catalysts for economic growth and enhancement of global living standards [73]. Enabling technologies plays crucial role in transforming renewable energy from a supplementary energy option into a major component of the global energy systems. Modern enabling technologies including advanced materials, manufacturing systems, electrotonic, nanotechnology, industrial biotechnology and photonics are intrinsically linked to global development trajectories [74]. Implement AI and machine learning algorithms to efficiently analyse large- scale data, enhancing system monitoring and control, while fostering innovation in energy storage technologies to ensure reliable backup and operational flexibility [75]. The technologies such as energy storage systems, smart grids, power electronics, digital monitoring and control systems, demand response mechanism, grid expansion and green hydrogen technologies. This system helps overcome major barrier associated with renewable energy integration, including intermittency, voltage and

frequency fluctuations, transmission limitations, and mismatches between energy generation and demand.

3.1 Energy Storage Systems

Energy storage systems are among the most important enabling technologies for renewable energy because they help manage the variability and intermittency of solar and wind power. Storage can shift electricity from periods of high renewable generation to periods of high demand, improve frequency regulation, reduce curtailment, and enhance grid reliability. The IEA also notes that distributed solar PV systems are increasingly being deployed together with storage, especially in regions with weak or unreliable grids [65]. These findings show that storage is not only a supportive technology but a central requirement for high-renewable power systems. Storage techniques are one of the most important enablers for decarbonization [67]. Recent studies show that advanced battery storage systems significantly increase renewable penetration in modern grids [76].

3.2 Smart Grids

Smart grids are critical enabling technologies because they allow electricity systems to operate more intelligently, flexibly, and efficiently as renewable penetration increases. Unlike conventional one-way grids, smart grids use real-time monitoring, digital communication, advanced metering, automated controls, and bidirectional power flow to balance generation and demand. The technological advances such as real-time smart meters, demand-side management, and advanced communication systems can greatly support renewable integration. In systems with high shares of distributed renewable generation, smart grids make it possible to coordinate rooftop solar, battery systems, electric vehicles, and flexible loads more effectively. Therefore, smart grids are a fundamental component of future renewable-dominant electricity systems. Recent research highlights that smart grid technologies improve reliability, resilience, and operational efficiency in high – renewable systems [77].

3.3 Grid Expansion and Modernization

Grid expansion and modernization are essential because renewable resources are often located far from demand centres, requiring new transmission corridors and upgraded distribution systems. Modernization and expansion of transmission networks are necessary to connect renewable rich regions with demand centres. Grid infrastructure

development is essential for large scale renewable integration and energy transition planning [67]. According to the IEA, the acceleration of renewable energy deployment calls for modernising distribution grids and building new transmission lines to connect remote renewable resources such as desert solar plants and offshore wind farms to cities and industrial loads. The IEA further reports that in 2025, global energy investment is expected to reach USD 3.3 trillion, of which around USD 2.2 trillion is going to renewables, nuclear, grids, storage, low-emissions fuels, efficiency, and electrification combined [78]. However, grid investment still lags behind what is needed for secure energy transitions. This indicates that grid infrastructure is one of the most decisive enabling technologies for future renewable deployment.

3.4 Power System Flexibility

Power system flexibility is a major enabling requirement for renewable energy integration. Flexibility refers to the ability of the energy system to respond to changes in electricity supply and demand across different time scales. This can be achieved through storage, flexible generation, transmission networks, demand response, improved forecasting, and wider balancing areas. NREL explains that high-renewable systems require a portfolio of flexibility options, including energy storage, quick-ramping resources, and responsive loads [79]. Another NREL report adds that maintaining reliability with high shares of renewables depends on combining variable renewable generation with dispatchable resources, transmission, and improved operational practices [80]. Flexibility is achieved through storage, demand response, interconnections, and flexible generation units. Studies confirms that increasing system flexibility reduces renewable curtailment and enhances system reliability [81].

3.5 Artificial Intelligence (AI) and Digitalization

Artificial Intelligence and digital technologies play major role forecasting renewable generation, optimizing grid operations, and improving energy managements. Digital tools such as advanced forecasting, real-time data analytics, automated dispatch, artificial intelligence, and network monitoring help improve efficiency and support renewable integration. NREL highlights that modern grids with high levels of variable renewable energy increasingly rely on communications, controls, and information systems [82]. These digital technologies help operators predict renewable output, optimize grid

operation, reduce system losses, and manage distributed assets more effectively. Thus, digitalization strengthens the technical capability of power systems to accommodate a growing share of renewable energy [82]. Recent research shows that AI- based models significantly enhance prediction accuracy and operational decision – making in smart grids [83].

3.6 Power Electronics

Power electronics are essential enabling technologies because most renewable energy systems, especially solar PV, batteries, and many wind systems, depend on inverters and converters for efficient operation and grid connection. As the share of inverter-based resources increases, advanced power electronics become necessary for voltage regulation, frequency support, power quality, and stable control of renewable-heavy grids. Modern research indicates that advanced power electronic systems are fundamental for stable operation of renewable rich grids [84]. The major challenge in modern grids is increasing level of power electronics based variable renewable energy.

This means that renewable integration is not only a matter of generation expansion but also of developing more advanced converter and control technologies to maintain stable grid performance.

3.7 Green Hydrogen

Green hydrogen is emerging as a major enabling technology for the renewable energy transition because it can connect renewable electricity with hard-to-abate sectors such as steel, chemicals, refining, shipping, and long-duration energy storage. It supports sector coupling between electricity, transport and industry. Recent studies confirms that hydrogen plays a crucial role in achieving net- zero energy systems [85]. IRENA's transition outlook identifies clean hydrogen as an important component of the 1.5°C energy pathway, especially where direct electrification is difficult [67]. The IEA also highlights the rapid scaling of electrolysers, the largest operational project was around 30 MW in 2021, a 500 MW project was commissioned in China in 2025, and the NEOM project in Saudi Arabia is targeting 2 GW by 2027 [68]. Hydrogen can store excess renewable electricity and later be converted back into power or used in industrial process, thereby improving overall system flexibility and reliability [86]. These developments

show that hydrogen is becoming an important bridge between renewable electricity and broader decarbonization across the economy.

4. Conclusion

Renewable energy sources have emerged as one of the most effective solutions for meeting the growing global energy demand while reducing environmental degradation and dependency on fossil fuels. Renewable energy sources offer significant potential for achieving cleaner, more sustainable, and secure energy future. However, the successful large-scale deployment of these energy sources depends not only on resources availability and generation technologies, but also on the development of strong supportive systems. Various enabling technologies such as energy storage, smart grids, grid modernization, power electronics, Artificial Intelligence (AI) and digital control systems, and green hydrogen play a crucial role in improving the reliability, flexibility and efficiency of renewable energy sources. The future of global energy systems will depend on the combined advancement of renewable generation technologies and enabling infrastructure. Continued research, policy support, investment, and technological innovation will be essential to accelerate this transition and to ensure that renewable energy can fully contribute to climate change mitigation, energy security and sustainable development. The renewable energy supported by enabling technologies, is expected to play central role in building a resilient and low carbon energy future.

References

1. Rawal, J., & Krishnanand. (**2019**, February). Renewable energy in India: Current status and future. *IRE Journals, 2*(8).
2. Kumar, C. R., & Majid, M. A. (**2020**). Renewable energy for sustainable development in India: Current status, future prospects, challenges, employment, and investment opportunities. *Energy, Sustainability and Society, 10*(2).
3. Benti, N. E., Chaka, M. D., & Semie, A. G. (**2023**). Forecasting renewable energy generation with machine learning and deep learning: Current advances and future prospects. *Sustainability, 15*, 7087.

4. Ahmed, R., & Tamim, M. T. R. (**2025**, September). The future of energy: Exploring renewable and non-renewable resources. *International Journal of Science Education and Science (IJSES), 2*(2), 85–100.
5. Arya, S., & Mahajan, P. (**2023**). Future in solar cell technology. In *Solar cells: Types and applications* (pp. 237–256). Springer Nature Singapore.
6. Karduri, R. K. R., & Ananth, C. (**2023**). Advancements in photovoltaic materials for sustainable energy generation. *International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST).*
7. Karduri, R. K. R., & Ananth, C. (**2023**). The role of policy in accelerating the energy transition. *International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST).*
8. Nwokediegwu, Z. Q. S., Ibekwe, K. I., Ilojianya, V. I., Etukudoh, E. A., & Ayorinde, O. B. (**2024**, February). Renewable energy technologies in engineering: A review of current developments and future prospects. *Engineering Science & Technology Journal, 5*(2).
9. Bouich, A., Pradas, I. G., Khan, M. A., & Khattak, Y. H. (**2023**). Opportunities, challenges, and future prospects of the solar cell market. *Sustainability, 15*, 15445.
10. Bathaei, A., & Štreimikienė, D. (**2023**). Renewable energy and sustainable agriculture: Review of indicators. *Sustainability, 15*, 14307.
11. Wang, F., Harindintwali, J. D., Yuan, Z., Wang, M., Wang, F., Li, S., Yin, Z., Huang, L., Fu, Y., Li, L., et al. (**2021**). Technologies and perspectives for achieving carbon neutrality. *Innovation, 2*, 100180.
12. Irfan, M., Zhao, Z.-Y., Ahmad, M., & Mukeshimana, M. (**2019**). Solar energy development in Pakistan: Barriers and policy recommendations. *Sustainability, 11*, 1206. https://doi.org/10.3390/su11051206
13. Izam, N. S. M. N., Itam, Z., Sing, W. L., & Syamsir, A. (**2022**). Sustainable development perspectives of solar energy technologies with focus on solar photovoltaic—A review. *Energies, 15*, 2790. https://doi.org/10.3390/en15082790
14. Shankar, R., Kumar, A., & Singh, A. (**2025**). A comprehensive review of load frequency control and solar energy integration: Challenges and opportunities in Indian context. *Energies, 18*, 843.

15. Obaideen, K., Shehata, N., Sayed, E. T., Abdelkareem, M. A., Mahmoud, M. S., & Olabi, A. G. (**2022**). The role of wastewater treatment in achieving sustainable development goals (SDGs) and sustainability guideline. *Energy Nexus, 7*, 100112.
16. Afridi, S. K., Alaas, Z. M., Koondhar, M., Jamali, M. I., Alsharif, M. H., Kim, M.-K., Aoudia, M., Mahariq, I., Touti, E., & Ahmed, M. M. R. A. (**2024**). Winds of progress: An in-depth exploration of offshore, floating, and onshore wind turbines as cornerstones for sustainable energy generation and environmental stewardship. *IEEE Access*. https://doi.org/10.1109/ACCESS.2024.3397243
17. Zou, H.-X., Zhao, L.-C., Gao, Q.-H., Zuo, L., Liu, F.-R., Tan, T., Wei, K.-X., & Zhang, W.-M. (**2019**). Mechanical modulations for enhancing energy harvesting: Principles, methods and applications. *Applied Energy, 255*, 113871. https://doi.org/10.1016/j.apenergy.2019.113871
18. Nacer, T., Hamidat, A., Nadjemi, O., & Bey, M. (**2016**). Feasibility study of grid-connected photovoltaic system in family farms for electricity generation in rural areas. *Renewable Energy, 96*, 305–318. https://doi.org/10.1016/j.renene.2016.04.064
19. Koondhar, M. A., Kaloi, G. S., Saand, A. S., Chandio, S., Ko, W., Park, S., Choi, H.-J., & El-Sehiemy, R. A. (**2023**). Critical technical issues with a voltage-source-converter-based high voltage direct current transmission system for the onshore integration of offshore wind farms. *Sustainability, 15*(18), 13526.
20. Bosi, S., Ramieri, E., Picciulin, M., Menegon, S., Ghezzo, M., Petrizzo, A., Folegot, T., Madricardo, F., & Barbanti, A. (**2023**). Is maritime spatial planning a tool to mitigate the impacts of underwater noise? A review of adopted and upcoming maritime spatial plans in Europe. *Marine Policy, 155*, 105725.
21. Chala, G. T., Ma'Arof, M. I. N., & Sharma, R. (**2019**). Trends in an increased dependence towards hydropower energy utilization—A short review. *Cogent Engineering, 6*, 1631541. https://doi.org/10.1080/23311916.2019.1631541
22. Pacific Northwest National Laboratory (PNNL). (**2023**). Open or closed: Pumped storage hydropower is on the rise. Retrieved May 16, 2023, from
23. International Hydropower Association. (**2023**). Pumped storage hydropower. Retrieved February 6, 2023,

24. Guruprasad, P. S. M., Quaranta, E., Coronado-Hernández, O. E., & Ramos, H. M. (**2023**). Hydropower advantages over batteries in energy storage of off-grid systems: A case study. *Energies, 16*, 6309.
25. Axelsson, G. (**2010**). Sustainable management of geothermal resources. In *Proceedings of the World Geothermal Congress*.
26. Li, K., Hu, Z., Li, H., et al. (**2015**). A review of geothermal energy development in China: Status, future prospects and policy implications. *Renewable and Sustainable Energy Reviews.*
27. Albertsson, A., & Stefánsson, A. (**2018**). Utilization of geothermal brine for recovery of minerals. *Minerals.*
28. Augustine, C. (**2016**). Updated US geothermal supply curve. *NREL Technical Report.*
29. Amhamed, A. I., Qarnain, S. S., Hewlett, S., Sodiq, A., Abdellatif, Y., Isaifan, R. J., & Alrebei, O. F. (**2022**). Ammonia production plants—A review. *Fuels, 3*(3), 408–435. https://doi.org/10.3390/fuels3030026
30. Aalrebei, O. F., Al Assaf, A. H., Amhamed, A., Swaminathan, N., & Hewlett, S. (**2022**). Ammonia-hydrogen-air gas turbine cycle and control analyses. *International Journal of Hydrogen Energy, 47*(13), 8603–8620. https://doi.org/10.1016/j.ijhydene.2021.12.123
31. Alrebi, O. F., Obeidat, B., Abdallah, I. A., Darwish, E. F., & Amhamed, A. (**2022**). Airflow dynamics in an emergency department: A CFD simulation study to analyse COVID-19 dispersion. *Alexandria Engineering Journal, 61*(5), 3435–3445. https://doi.org/10.1016/j.aej.2021.08.043
32. Amhamed, A. I., Al Assaf, A. H., Le Page, L. M., & Alrebei, O. F. (**2024**). Alternative sustainable aviation fuel and energy (SAFE): A review with selected simulation cases of study. *Energy Reports, 11*, 3317–3344.
33. Alrebei, O. F., Obeidat, L. M., Ma'bdeh, S. N., Kaouri, K., Al-Radaideh, T., & Amhamed, A. I. (**2022**). Window-windcatcher for enhanced thermal comfort, natural ventilation and reduced COVID-19 transmission. *Buildings, 12*(6), 791.
34. Alrebei, O. F., Al-Doboon, A., Bowen, P., & Valera Medina, A. (2019). CO_2 argon-steam oxy-fuel production for (CARSOXY) gas turbines. *Energies, 12*(18), 3580.
35. Alrebei, O. F., Bowen, P., & Valera Medina, A. (**2020**). Parametric study of various thermodynamic cycles for the use of unconventional blends. *Energies, 13*(18), 4656.

36. Alrebei, O. F., Al Assaf, A. H., Al-Kuwari, M. S., & Amhamed, A. I. (**2022**). Lightweight methane-air gas turbine controller and simulator. *Energy Conversion and Management: X, 15*, 100242.
37. Obeidat, B., Alrebei, O. F., Abdallah, I. A., Darwish, E. F., & Amhamed, A. (**2021**). CFD analyses: The effect of pressure suction and airflow velocity on coronavirus dispersal. *Applied Sciences, 11*(16), 7450.
38. Obeidat, L. M., Alrebei, O. F., Ma'bdeh, S. N., Al-Radaideh, T., & Amhamed, A. I. (**2023**). Parametric enhancement of a window-windcatcher for enhanced thermal comfort and natural ventilation. *Atmosphere, 14*(5), 844.
39. Ma'bdeh, S. N., Alrebei, O. F., Obeidat, L. M., Al-Radaideh, T., Kaouri, K., & Amhamed, A. I. (**2023**). Quantifying energy reduction and thermal comfort for a residential building ventilated with a window-windcatcher: A case study. *Buildings, 13*(1), 86.
40. Khalil, I. A., & DanielRos, M. (**2025**, September 1). Biomass energy: Pathways, potentials, and challenges for a sustainable energy future. *Energy Conversions Available Online*.
41. Ma'bdeh, S. N., Hamasha, A. A., Al-Shawabkeh, M., Alali, R. O., Almomani, R. M., Obeidat, L. M., & Alrebei, O. F. (**2025**). Enhancing office air quality: The role of window to wall ratio with window-wind catchers using CFD analysis. *Energy Reports, 13*, 1508–1524.
42. Al-Assaf, A. H., Alrebei, O., Amhamed, A., Hayajnh, M. A., Fawaz, W., & Al-Tawaha, A. S. (**2021**). PID power controller to a setpoint of fluid level height in a reservoir for unattended human monitoring. *International Journal of Electrical and Electronics Engineering Studies, 8*, 1–13.
43. Ma'bdeh, S. N., Alali, R. O., Al-Shawabkeh, M., Almomani, R. M., Hamasha, A. A., Shannik, R., & Alrebei, O. F. (**2025**). Optimizing airflow in double-skin facades: Influence of vents design and cavity depth. *Cleaner Engineering and Technology, 26*, 100980.
44. Assaf, A. H., Ahmed, A., Mahaftha, D. M., Amhamed, A. I., Alrebei, O. F., & Jarrah, B. A. (**2024**). NH_3–H_2 working fluid-based shell and tube heat exchanger and the H_2O-to-H_2O helical heat exchanger: A novel integration to ammonia production plants. *Jordan Journal of Mechanical & Industrial Engineering, 18*(2).

45. Al Assaf, A. H., & Alrebei, O. F. (**2022**). Electrical unmanned ground vehicle controller. *International Journal of Electrical and Electronics Engineering Studies, 7*(1), 35–46.
46. Ayasra, O., & Alrebei, O. F. (**2021**). The role of e-marketing in supporting tourist destinations in Jordan: Case study Petra. *European Journal of Hospitality and Tourism Research, 9*(4), 43–57.
47. Elshukri, F., Abusirriya, N. H., Braganza, N. J., Amhamed, A., & Alrebei, O. F. (**2025**). Temporal and spatial pattern analysis and forecasting of methane: Satellite image processing. *Ecological Informatics, 89*, 103176.
48. Al-Assaf, A. H., Alrebei, O., Amhamed, A., Hayajnh, M. A., Fawaz, W., & Al-Tawaha, A. S. (**2021**). PID power controller to a setpoint of fluid level height in a reservoir for unattended human monitoring. *International Journal of Electrical and Electronics Engineering Studies, 8*, 1–13.
49. Al Assaf, A. H., & Alrebei, O. F. (**2022**). Increasing the energy balance of hydrocarbon production from *B. braunii* with inclined solid–liquid separation and easy hydrocarbon recovery. *Interdisciplinary Journal of Agriculture and Environmental Sciences, 9*(1).
50. Khayal, O. M. E. S. (**2025**). Biomass energy – Past, present, and future prospects: A review. *Journal of Emerging Technologies and Novel Research, 3*(10).
51. Crippa, M., Guizzardi, D., Pagani, F., Banja, M., Muntean, M., Schaaf, E., et al. (**2023**). *GHG emissions of all world countries*. Publications Office of the European Union.
52. Omondi, A., Khatiwada, D., Melts, I., Wada, N., & Geetha, M. (**2026**). Revitalizing biomass utilization for renewable energy and sustainable rural development in Japan. *Discover Sustainability, 7*, 410.
53. Karm, H., Husam, F., & Saif, A. N. (**2025**, September 1). Geothermal energy: Pathways, technologies, and prospects for sustainable power generation. *Energy Conversions Available Online*.
54. Alrebei, O. F., Bowen, P., & Valera Medina, A. (**2020**). Parametric study of various thermodynamic cycles for the use of unconventional blends. *Energies, 13*(18), 4656.
55. Stefánsson, V. (**2000**). Geothermal energy: Success stories. *Renewable Energy*.
56. Sanyal, S. K. (**2005**). Cost of geothermal power and factors that affect it. *Geothermal Resources Council Transactions*.

57. Alrebei, O. F. A. (**2019**). *Carbon dioxide-argon-steam oxyfuel (CARSOXY) gas turbines* (Doctoral dissertation, Cardiff University).
58. Charlier, R. H. (**2007**). Forty candles for the Rance River TPP: Tides provide renewable and sustainable power generation. *Renewable and Sustainable Energy Reviews, 11*, 2032–2057.
59. Chowdhury, M. S., Rahman, K. S., Selvanathan, V., Nuthammachot, N., Suklueng, M., Mostafaeipour, A., Habib, A., Akhtaruzzaman, M., Amin, N., & Techato, K. (**2021**). Current trends and prospects of tidal energy technology. *Environment, Development and Sustainability, 23*, 8179–8194.
60. Neill, S. P., Haas, K. A., Thiebot, J., & Yang, Z. (**2021**). A review of tidal energy—Resource, feedbacks, and environmental interactions. *Journal of Renewable and Sustainable Energy, 13*, 062702.
61. Khan, N., Kalair, A., Abas, N., & Haider, A. (**2017**). Review of ocean tidal, wave and thermal energy technologies. *Renewable and Sustainable Energy Reviews, 72*, 590–604.
62. Borthwick, A. G. L. (**2016**). Marine renewable energy seascape. *Engineering, 2*, 69–78.
63. Paredes, M. G., Padilla-Rivera, A., & Güereca, L. P. (**2019**). Life cycle assessment of ocean energy technologies: A systematic review. *Journal of Marine Science and Engineering, 7*, 322. https://doi.org/10.3390/jmse7090322
64. Sitompul, H., Hidayat, K., Hutahayan, B., & Sunarti. (**2024**). Analyzing factors influencing renewable energy utilization: A bibliometric review. *BICBATT 2024*.
65. International Energy Agency. (**2025**). *Renewable electricity: Renewables 2025*.
66. Magableh, G. M., & Bazel, N. K. (**2025**). Exploring future renewable energy technologies using a developed model and a variety of MCDM approaches. *Sustainability, 17*, 3057.
67. International Renewable Energy Agency. (**2024**). *World energy transition outlook 2024: 1.5°C pathway*.
68. International Energy Agency. (**2025**). *Executive summary – Renewables 2025*.
69. Intergovernmental Panel on Climate Change. (**2011**). *Renewable energy sources and climate change mitigation*.
70. Ahmed, S., Ali, A., Ciocia, A., & D'Angola, A. (**2024**). Technological elements behind the renewable energy community: Current status, existing gap, necessity, and future perspective—Overview. *Energies, 17*, 3100.

71. United Nations Environment Programme. (**2025**). *Emission gap report 2025*.
72. Karmarkar, N. (**2025**). Renewable energy futures: Barriers, impacts, and policy solution. *Indian Journal of Natural Sciences and Engineering, 16*(96).
73. Şalvarlı, H. (**2023**). Some views on clean energy and enabling technologies for sustainable development. *Journal of Sustainable Energy & Environment, 14*, 31–37.
74. Salvarli, M. S., & Salvarli, H. (**2020**). For sustainable development: Future trends in renewable energy and enabling technologies. In *Renewable energy—Resources, challenges and applications*. IntechOpen. https://doi.org/10.5772/intechopen.91842
75. Guan, C., Li, Z., & Lin, D. (**2024**). Power system stability: Concepts, trends, and future challenges. *Advances in Resources Research, 4*(1), 55–66.
76. Liu, J., Li, Y., & Zhang, H. (**2023**). Grid-scale energy storage systems for renewable integration: A comprehensive review. *Renewable and Sustainable Energy Reviews, 173*, 113058.
77. Ahmed, M. A., & Kim, H. S. (**2022**). Smart grid technologies for renewable energy integration: A review and future trends. *Applied Energy, 306*, 118065.
78. International Energy Agency. (**2025**). *World energy investment 2025: Executive summary*.
79. National Renewable Energy Laboratory. (**2015**). *Advancing system flexibility for high penetration renewable integration*.
80. National Renewable Energy Laboratory. (**2024**). *Maintaining grid reliability: Lessons from renewable integration*.
81. Sharma, P., Singh, R., & Ghosh, S. (**2021**). Power system flexibility and renewable energy integration: Recent advancement. *IEEE Access, 9*, 134789–134805.
82. National Renewable Energy Laboratory. (**2017**). *Integrating high levels of variable renewable energy into power systems*.
83. Wang, Q., Li, Y., & Chen, Z. (**2022**). Artificial intelligence in smart grids: Applications and challenges. *Renewable Energy, 186*, 1223–1237.
84. Kumar, A., & Nair, S. (**2020**). Power electronics for renewable energy systems: A modern review. *IEEE Transactions on Power Electronics, 35*(9), 8765–8780.
85. International Energy Agency. (**2025**). *Global hydrogen review 2025*. Paris: IEA.

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

86. Liu, Z., Adams, T. A., & Barton, P. I. (**2020**). Optimal design and operation of hydrogen energy storage systems for renewable energy integration. *Applied Energy, 262*, 114574.

E-ISSN: 3049-3846

International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

INTEGRATING SUSTAINABILITY INTO HIGHER EDUCATION CURRICULUM

Prof. Manasi Milind Pawar

Adv M.N. deshmukh Arts, Science, and Commerce college, Rajur
Tal- Akole Dist- Ahilaynagar,
Mob No – 9607718143
Email- pawarmanasi843@gmail.com

Abstract

Sustainable development has become a global priority due to environmental degradation, climate change, and increasing socio-economic inequalities. Higher education institutions play a crucial role in promoting sustainability by preparing future leaders, professionals, and policymakers. Integrating sustainability into higher education curricula enables students to develop the knowledge, skills, and values needed to address global challenges. This research paper explores the importance of sustainability education in universities, strategies for integrating sustainability into academic programs, challenges faced by institutions, and recommendations for effective implementation. The study concludes that interdisciplinary learning, institutional commitment, and innovative teaching methods are essential for successfully embedding sustainability in higher education systems.

1. Introduction

Sustainable development is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland Commission, 1987). Rapid industrialisation, environmental degradation, and climate change have created an urgent need for sustainable solutions across economic, environmental, and social systems.

Education plays a vital role in promoting sustainability because it shapes attitudes, values, and behaviours. Higher education institutions are particularly important because they produce the

researchers, professionals, and policymakers who influence societal development (Leal Filho et al., 2015).

Universities contribute to sustainable development through teaching, research, and community engagement. Integrating sustainability into university curricula allows students to understand environmental issues, develop critical thinking skills, and apply sustainable practices in their professional careers. Education systems that emphasise sustainability help prepare students to address complex global challenges such as climate change, resource scarcity, and social inequality (UNESCO, 2017).

Therefore, integrating sustainability into higher education curricula has become an important strategy for achieving long-term sustainable development.

2. Concept of Sustainable Development in Higher Education

Sustainable development is a holistic concept that integrates environmental protection, economic development, and social equity. In higher education, sustainability refers to the incorporation of these principles into teaching, research, campus operations, and community engagement (Sterling, 2013).

Education for Sustainable Development (ESD) aims to equip learners with the knowledge and competencies to contribute to sustainable societies. According to UNESCO (2017), ESD encourages critical thinking, problem-solving, and participatory decision-making.

Higher education institutions play a significant role in sustainability because they influence future generations of leaders and professionals. Universities can promote sustainability by developing environmentally responsible policies, conducting research on sustainability challenges, and incorporating sustainability topics into their academic programs (Leal Filho et al., 2015).

Integrating sustainability into education also helps students understand the interconnections between environmental, economic, and social systems. This understanding is necessary for addressing global issues such as climate change, poverty, and resource management.

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

3. Role of Sustainable Development Goals in Higher Education

The concept of Sustainable Development Goals (SDGs) has become a key framework for addressing global challenges such as poverty, climate change, environmental degradation, and social inequality. In 2015, the United Nations adopted **17 Sustainable Development Goals** as part of the 2030 Agenda for Sustainable Development. These goals aim to promote inclusive growth, environmental protection, and social well-being across the world.

Higher education institutions play a significant role in achieving these goals through education, research, and innovation. Universities are responsible for preparing students with the knowledge and skills required to address global sustainability challenges. By integrating sustainability into academic curricula, universities can help students understand the importance of sustainable development and encourage responsible decision-making.

One of the most important goals related to education is **Sustainable Development Goal 4**, which aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. Higher education institutions contribute to this goal by improving access to quality education and incorporating sustainability principles into teaching and learning processes.

Universities also support other goals such as **Sustainable Development Goal 13**, which focuses on addressing climate change, and **Sustainable Development Goal 12**, which encourages sustainable resource use. Through research initiatives, sustainability programs, and green campus policies, universities can promote environmental responsibility and sustainable lifestyles.

Furthermore, higher education institutions serve as platforms for innovation and collaboration. By conducting research on renewable energy, sustainable agriculture, and environmental conservation, universities contribute to the development of sustainable solutions for global challenges. Universities also collaborate with governments, industries, and communities to implement sustainability initiatives.

Therefore, integrating Sustainable Development Goals into higher education curricula is essential for preparing students to become responsible global citizens who can contribute to sustainable development. Universities that align their academic programs with the SDGs play a crucial role in building a more sustainable and equitable future.

4. Importance of Integrating Sustainability into Higher Education Curriculum

4.1 Promoting Environmental Awareness

One of the primary benefits of sustainability education is increasing awareness about environmental challenges. Students learn about issues such as climate change, biodiversity loss, and pollution, which encourages them to adopt environmentally responsible behaviours (Sterling, 2013).

4.2 Developing Critical Thinking Skills

Sustainability education encourages students to analyse complex global problems from multiple perspectives. This approach enhances critical thinking and problem-solving skills, which are essential for addressing sustainability challenges.

4.3 Preparing Future Professionals

Graduates from universities enter professions such as engineering, business, healthcare, and government. Integrating sustainability into education ensures that these professionals are capable of implementing sustainable practices in their respective fields (Leal Filho et al., 2015).

4.4 Supporting Global Sustainability Goals

Higher education institutions contribute to global sustainability efforts by educating students about sustainable development principles. Universities also conduct research that helps develop innovative solutions for environmental and social problems (UNESCO, 2017).

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

4.5 Encouraging Responsible Citizenship

Sustainability education promotes ethical values, social responsibility, and global citizenship. Students learn to consider the long-term consequences of their decisions and actions, which helps build a more sustainable society.

5. Strategies for Integrating Sustainability into Higher Education Curriculum

5.1 Interdisciplinary Learning

Sustainability challenges are complex and require knowledge from multiple disciplines. Universities can integrate sustainability by offering interdisciplinary courses that combine environmental science, economics, social sciences, and technology (Sterling, 2013).

5.2 Project-Based Learning

Project-based learning allows students to apply theoretical knowledge to real-world sustainability problems. Students may work on projects related to renewable energy, waste management, or community sustainability initiatives.

5.3 Curriculum Integration Across Disciplines

Sustainability should not be limited to environmental science programs. Instead, universities should integrate sustainability concepts across all disciplines, including business, engineering, healthcare, and social sciences (Leal Filho et al., 2015).

5.4 Faculty Development and Training

Educators play a crucial role in implementing sustainability education. Universities should provide professional development programs that help faculty members incorporate sustainability topics into their courses.

5.5 Institutional Commitment

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Successful integration of sustainability requires institutional support. Universities must adopt policies that encourage sustainability research, teaching, and campus initiatives.

5.6 Community and Industry Collaboration

Collaborations between universities, industries, and communities can strengthen sustainability education. Such partnerships allow students to work on real-world projects and gain practical experience in solving sustainability challenges.

6. Challenges in Integrating Sustainability into Higher Education Curriculum

Despite its importance, several challenges hinder the integration of sustainability into university curricula.

6.1 Lack of Awareness

Many educators and students are not fully aware of sustainability concepts. This lack of awareness makes it difficult to incorporate sustainability topics into teaching.

6.2 Institutional Barriers

Some universities lack the administrative support, funding, and infrastructure required for implementing sustainability programs (Leal Filho et al., 2015).

6.3 Resistance to Curriculum Change

Faculty members who are accustomed to traditional teaching methods may resist curriculum reforms that involve sustainability education.

6.4 Limited Resources

Developing sustainability programs often requires financial resources, training programs, and specialised materials, which may not always be available.

6.5 Lack of Faculty Expertise

E-ISSN: 3049-3846
International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)
A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

Many educators have limited training in sustainability, which affects their ability to effectively teach sustainability-related subjects

7. Recommendations for Effective Implementation

Several strategies can help universities successfully integrate sustainability into their curriculum.

First, sustainability should be included as a core component of higher education programs across disciplines.

Second, universities should provide training and professional development opportunities for faculty members to improve their understanding of sustainability education.

Third, institutions should promote interdisciplinary collaboration among departments to encourage comprehensive sustainability learning.

Fourth, universities should integrate sustainability into campus operations such as energy management, waste reduction, and sustainable transportation. This allows students to observe sustainability practices in real-life settings.

Fifth, governments and policymakers should provide financial support and incentives for universities that implement sustainability education programs.

Finally, universities should encourage students to participate in sustainability initiatives, research projects, and community engagement activities.

8. Conclusion

Integrating sustainability into higher education curricula is essential for addressing global environmental and social challenges. Universities play a crucial role in preparing future leaders who can contribute to sustainable development.

Sustainability education enhances students' knowledge, critical thinking skills, and ethical values. By adopting interdisciplinary approaches, project-based learning, and institutional commitment, universities can effectively integrate sustainability into their educational systems.

However, challenges such as lack of awareness, limited resources, and resistance to curriculum change must be addressed. Collaboration between universities, governments, and communities is necessary to promote sustainability education.

Ultimately, integrating sustainability into higher education will help create a generation of responsible citizens capable of building a sustainable and equitable future.

References (APA Style)

- Sustainable Development Goals M.com second year Book
- Brundtland Commission. (1987). *Our common future*. Oxford University Press.
- Leal Filho, W., Manolas, E., & Pace, P. (2015). The future we want: Key issues on sustainable development in higher education after Rio and the UN decade of education for sustainable development. *International Journal of Sustainability in Higher Education*, 16(1), 112–129.
- Sterling, S. (2013). *The sustainable university: Progress and prospects*. Routledge.
- UNESCO. (2017). *Education for sustainable development goals: Learning objectives*. United Nations Educational, Scientific and Cultural Organisation.