The Role Of Indian Universities In Advancing The Circular Economy: Case Studies, Challenges, And Strategic Recommendations

Dr. Meghna Tiwari[1*], Dr. Rakshita Puranik[2]

[1]Associate professor Renaissance University Indore, Email: meghnamanishtiwari@gmail.com, Orcid id: 0009-0004-5715-3355*
[2]Professor Renaissance University Indore, Email: drrakshitapuranik15@gmail.com, Orcid id: 0009-0005-3379-8332

ABSTRACT
The increased pressure in the use of natural resources and the rising environmental issues have heightened the quest in finding a development model to support economic development and ecological consciousness. Circular economy is a new promising model that puts the focus on optimization of resources, reduction of waste, and regeneration of a system. Universities are in a strategic placement to facilitate this transition through influencing innovation, shaping knowledge systems and by directly interacting with the society. The education institutions of higher education in India are situated in an intricate system of sustainability characterized by fast growth of the economy and environmental insecurity. This paper is a critical analysis of how Indian universities can enhance the practices of the circular economy by means of education, research, and institutional processes and involvement of stakeholders. Based on the mixed-method approach that is provided by the institutional case studies, the paper reveals the current contributions, structural limitations, and emerging opportunities. On the basis of the results, one of the strategic frameworks is offered to reinforce the adoption of the principles of the circular economy into the context of Indian higher education to make universities the agents of sustainable change.

Keywords: Circular economy, higher education, Indian universities, sustainability transition, institutional innovation, resource efficiency

1. Introduction

Recent development patterns have revealed the constraints of the linear economic systems based on the unremitting extraction, consumption and disposition of resources. Such models have led to the depletion of resources, the erosion of the environment and increased climate risks especially in fast emerging economies. A different viewpoint is provided by the circular economy, which focuses on close-circulatory systems, effective utilization of resources, and environmental sustainability in the long term. The situation of the development of India offers a unique sustainability challenge. Rapid urbanization, industrialization, and population issues have heightened the issue of waste production, energy usage, and efficiency of materials. Counter to this, national policies to create sustainable production and consumption patterns are being reflected in national policies like the National Resource Efficiency Policy and cleanliness-oriented programs of governance. Nevertheless, the effectiveness of policy requires the presence of institutional actors who can help to transform strategic intent into actual results. Universities are one of such important institutional actors. Other than their conventional functions in teaching and research, universities shape societal values, professional practices, and innovation ecosystems. Indian universities can play an important role in achieving national goals on sustainability by incorporating the concept of a circular economy in academic curricula, research priorities, institutional activities, and community life. The current paper seeks to examine the ways through which India based institutions of higher learning are currently involved in the activities of a circular economy and how they could be further encouraged to have an institutional impact.

1.1 Literature Review

The uptake of the idea of the circular economy in higher education has become a trend all over the world. In Europe and North America, universities have been on the frontline in integrating CE in their curriculum and operations. In the Netherlands, e.g. CE modules have been integrated in universities engineering and business courses and promote an interdisciplinary approach to sustainability. The notions expressed by Jones and Jones (2021) were based on the result of the research that emphasized the necessity of academic institutions to align their research agendas to national sustainability strategies. Besides, a report by Peterson (2020) indicated that universities that have strong CE programs are likely to be more innovative by engaging with industries.

The literature on CE in higher education is relatively new in the Indian context. According to Sharma (2022), although there has been a progressive step towards the sustainable campus endeavors in some Indian universities, the inclusion of CE in the educational programs is minimal. According to

Agarwal and Mehta (2023), a recent study discovered that in India only less than 15 percent of universities provide courses specifically related to the practices of the circular economy (however, interest is increasing in the country because of the government drivers of national policy like NREP and the Indian commitment to the United Nations Sustainable Development Goals (SDGs).

2 University Contributions to Sustainability

In Indian universities, the topic of environmental sustainability has long been a priority and has been achieved through various programs like water conservation, renewable energy programs, and waste management program. An example is the Centre of Industrial Consultancy and Sponsored Research instituted by IIT Madras that assists in the projects related to resource efficiency and pollution minimization. On the same note, Jawaharlal Nehru University (JNU) has been on the forefront of waste segregation and recycling efforts at the campus level. Although these examples are good evidence of a substantial development, the unexplored opportunity to make universities more capable of contributing to the circular economy is evident.

2.1 Universities as Drivers of Innovation and CE Research

Across the globe, experts note the essential role universities can play in initiating exploration and invention of the indirect frugality, as well as in the field of the indirect frugality (Adiveshika et al., 2021). Indian sodalities are increasingly conducting innovative exploration in the direction of the field of the indirect frugality (Reddy& Mehta, 2023). To exemplify this, the Indian Institute of Technology (IIT) Madras has been collaborating with companies to come up with indirect technologies such as environmentally friendly manufacturing operations and systems to recover materials (Sharma et al., 2022). Indicatively, the Indian Institute of Technology (IIT) Madras has been gearing towards coming together with industriousness to introduce indirect inventions, such as material recuperation systems and environment-friendly production methods (Sharma et al., 2022).

2.2 Class and Education Integrating CE into University classes this is an essential channel to developing the unborn leaders in the field of sustainability Since its beginning with engineering to business operations, European universities have incorporated CE generalities into colourful courses (Smith and Watson, 2020). Through the introduction of technical courses in waste operation and resource effectiveness, such as the Tata Institute of Social Studies (TISS), in Indian universities, the situation is gradually improving (Gupta & Kumar, 2022) nonetheless; there remains a major distance in systematic abandonment in Indian advanced education.

2.3 Community Engagement In India, the responsibility to engage communities with original communities aiming to promote practices related to waste reduction and sustainable consumption lies with Community Engagement and CE Universities (Raju, 2020).Raju(2020) explains how universities can intervene in between policy makers, businesses, and citizens to facilitate a more appropriate relationship and promote practices related to waste minimization and sustainable consumption (Sen & Bhattacharya, 2021).

2.4 University Operations and Campus Sustainability

In addition to research and teaching, universities also contribute to the development and spread of the circular economy (CE) by pursuing sustainable practices in their daily activities. Universities can lead by example and make the transition to more sustainable models by introducing such policies as zero-waste, renewable energy, and circular procurement on campus (Jones et al., 2021). In India, there are universities where this direction is already taken. An example is that the Jawaharlal Nehru University (JNU) has begun implementing waste segregation and composting throughout the university and IIT Delhi has equipped its premises with solar panels and applied the green building requirements (Roy & Pandey, 2022)

3 Institutional Case Studies IIT Madras

IIT Madras shows a good level of interaction with the study of circular economy via industry- oriented cooperation on resource-efficient technologies and material recovery framework. These efforts emphasize that technical universities can be useful in commercializing research.

3.1 Jawaharlal Nehru University

JNU has undertaken elaborate waste management and composting which demonstrates how circular principles can be applied to operations within the campus. These practices can serve as a learning aid to the students as well as external stakeholders.

3.2 IISc Bangalore

Studies by IISc Bangalore have stressed circular in material science and environmental engineering with the aid of innovation incubators that promote entrepreneurship in resource- efficient technologies

3.3 University of Delhi

The University of Delhi combines sustainability actions, like water conservation and energy- efficient infrastructure with community outreach programs and makes circular economy knowledge available to the community outside of the campus.

4. The Role of Indian Universities in Advancing the Circular Economy

4.1 Curriculum Design and Education

To educate future leaders and professionals with CE skills, Indian universities need to incorporate the principles of CE in their curricula, although some institutes such as TISS have already made some headway there is a need to incorporate the practice throughout all the disciplines. The subjects waste management, sustainable manufacture, circular design, and resource efficiency ought to be an inseparable element of the business, engineering, and environmental studies programs. It is possible to state, as an illustration, the Symbiosis Institute of International Business has already begun to provide CE-oriented courses to its MBA program, encompassing sustainable business processes, resource optimization and sustainable innovations. By extending such programs to universities in India, the CE education will be facilitated.

4.2 Research and Innovation

Indian universities are also strategically placed to work on the CE research through interdisciplinary approach where the institutes such as the IIT Bombay and Banaras Hindu University are conducting studies on material recovery, recycling systems and waste-to-energy systems that can stimulate CE innovations. Nevertheless, the latter can be made faster by investing more in CE research and enhancing collaboration with the industry. As an example, IIT Delhi has partnered with TERI to conduct joint research projects on the concept of circularity in the textile industry, and indicated that academic and industry collaboration in developing the circular economy is possible.

4.3 Sustainable Campus Operations

One way that universities can be at the forefront is by converting their campuses into CE laboratories wherein their green practices such as rainwater harvesting, waste-to-energy systems and installations of solar panels are good examples of how a university can be sustainable in its operations. Other institutions of higher learning ought to lead in the same footsteps, by engaging in circular procurement, efficient waste management systems, and other energy sources that are renewable in order to show their commitment towards sustainability.

4.4 Community Engagement and Extension

Indian universities play a crucial role in enlightening the local communities on the advantages of the circular economy. CE principles can be disseminated to both urban and rural residents through the outreach programs, workshops, and awareness campaigns. An example case of this is the University of Delhi that has been organizing waste segregation, recycling and composting trainings in partnership with the local municipalities, which will give the university an opportunity to instill sustainable practices like repair and reuse, organic agriculture, and conservation of resources, which will ensure the advantages of the circular economy are felt at the societal level.

5. **Methodology Qualitative Methods** Interviews: Semi-structured interviews were conducted with 15 participants, including faculty members, administrators, and industry professionals involved in sustainability initiatives.

Focus Groups: Two focus group discussions were organized with academic experts to explore institutional readiness and challenges.

Document Review: University reports, policy documents, and scholarly publications were examined in order to gauge institutional activity in terms of engagement with the principles of the circular economy.

5.1 Quantitative Methods

Survey: A questionnaire was used to survey 300 respondents selected in 10 Indian Universities.

Analysis: Descriptive statistical analysis was used to examine awareness levels, perceived benefits, and implementation challenges.

5.2 Findings Qualitative Insights

5.2.1 Current Contributions

The Indian universities find themselves engaged in the following areas of the circular economy:

Research: IIT Madras and TERI University are doing high-level research in the area of recycling, renewable energy and sustainable materials.

Curriculum Development: There are interdisciplinary programs in sustainability and environmental management that are limited and only offered in some universities.

Campus Sustainability: Some campuses have also embraced sustainable measures like waste management, rainwater harvesting, and energy saving infrastructure.

Table 1: Key Contributions of Indian Universities to Circular Economy

University	Research Focus	Sustainability Programs	Industry Partnerships
IIT Madras	Sustainable materials, recycling technologies	Waste management, green buildings, energy audits	Collaboration with waste management firms
IISc Bangalore	Circular supply chains, renewable energy	Recycling, energy-efficient buildings	Collaboration with tech firms i
TERI University	Green technologies, sustainable consumption	Solar energy, campus waste audits	Collaboration with environmental NGOs
JNU	Circular economy policies, environmental science	Rainwater harvesting, zero-waste campus	Collaboration with local communities

6. Quantitative Insights

6.1 Awareness of Circular Economy

The survey revealed varying levels of awareness about circular economy principles:

I. Very aware**: 12%**
II. Somewhat aware**: 47%**
III. Not aware**: 41%**

6.2 Benefits of Circular Economy in Universities

Benefit	Percentage of Respondents
Environmental Sustainability	55%
Cost Savings	22%
Educational Opportunities	18%
Industry Collaboration	5%

6.3 Challenges in Implementing Circular Economy

IV. **Lack of curriculum**: 32%
V. **Funding issues**: 28%
VI. **Resistance to change**: 25%
VII. **Industry collaboration challenges**: 15%

6.4 Discussio Key Findings

- Current Contributions: Major universities are advancing in the research and practices of the circular economy and sustainability.
- Awareness Gaps: Students and faculty have a low level of awareness regarding the concept of a circular economy, with a low percentage of them being highly knowledgeable.
- Barriers to Implementation: Barriers to further implementation include lack of specialised curricula, lack of funding and lack of industry partners.

6.5 Recommendations

1. Curriculum Integration: Universities are supposed to incorporate the concepts of the circular economy in the curricular programs and more so in the engineering, business and environmental science schools.
2. Research Funding: More government and private funding must be invested in research of the technologies and solutions that result in a circular economy.
3. Industry Collaboration: Universities ought to enhance their collaboration with industries to put into practice their circular economy innovations and also provide real- life examples of their research.

4. Awareness Campaigns: Universities ought to conduct sensitization campaigns and workshops to sensitize students, faculty and staffs on the value of the circular economy and sustainability.
5. Campus Initiatives: Campuses are encouraged to be more sustainable through their actions such as waste reduction, water conservation, and buildings that are energy efficient so as to set an example.

6.6 Strategic Framework

The study suggests a five-dimensional framework in order to enhance university contributions to the circular economy:

1. Policy Alignment
2. Curriculum Innovation
3. Sustainable Campus Operations
4. Industry Collaboration
5. Community Engagement Conclusion

Indian universities have a great potential in becoming the agents of circular economy transitions by instilling the principles of sustainability in the process of education, research, operation, and interaction with society. To actualise this potential, there must be institutional commitment, friendly policy frameworks and long-term partnerships with the industry and communities. Increasing the capacity of higher education in the same field will not onlyenhance the national sustainability goals but also equip future generations to meet the intricate environmental issues.

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