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Original Research Article

Indigenous Wisdom and Circular Economy: A Case Analysis of Traditional Sustainable Practices in Indian Tribal Communities

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Abstract: Indigenous communities across the Indian subcontinent have, for millennia, practiced principles that align closely with what is now recognized as the circular economy. Their ways of life, deeply inter-twined with nature, establishing sustainable resource management and regenerative ecological systems. This research adopts a qualitative approach, relying on the analysis of existing case studies to explore how Indian tribal communities have historically embodied the essence of the circular economy. The study synthesizes insights from multiple documented cases, drawing upon ethnographic records, environmental studies, and community development reports to interpret the cyclical and sustainable nature of indigenous resource practices. The findings from these analyzed cases reveal that traditional Indian tribal societies have long implemented efficient and regenerative systems through locally developed knowledge frameworks. Practices such as zero-waste agriculture, where every by-product of cultivation is reused or reintegrated into the ecosystem, demonstrate remarkable ecological foresight. Community-based systems of sharing and collective ownership further minimize waste and ensure equitable distribution of resources. This study concludes that the traditional practices of Indian tribal communities represent well-established models of circular living long before the term "circular economy" was conceptualized in modern discourse. By revisiting and integrating these indigenous models into present-day sustainability frameworks, policymakers and environmental planners can develop holistic, culturally grounded strategies that not only promote resource efficiency but also strengthen community resilience and ecological harmony.

Keywords: Circular Economy, Community Resilience, Indigenous Knowledge, Indian Tribes, Resource Management, Sustainable Practices, Traditional Ecological Knowledge.

INTRODUCTION

The concept of the circular economy (CE) has rapidly gained currency in global sustainability discourse as an alternative to the conventional linear model of "take-make-dispose". Driven by concerns over resource depletion, climate change, and waste accumulation, CE frameworks emphasize reducing waste, reusing materials, recycling, remanufacturing, and designing systems for resilience (Pal, Gaur, Raj *et al*., 2025). The evolution of CE thinking has moved from early definitions focusing on material flows to more complex understandings that integrate social, economic, and cultural dimensions (Atabaki Fard, Sarkar, & Shetranjiwalla, 2025). Recognizing that material recovery alone is insufficient, scholars now examine how communities maintain value across product life cycles, preserve ecological integrity, and embed equity and local practices into circular systems.

Indigenous knowledge systems (IKS) offer fertile terrain for these broader understandings. Across many parts of the world, indigenous communities have long operated according to regenerative ecological principles managing land and water, biodiversity, agriculture, and material flows through practices that are inherently circular. These practices are not just ecological; they integrate culture, social norms, communal governance, and reciprocity. Recent work in India has begun to document how IKS contributes to sustainable agriculture and food systems; for example, millets farming in Koraput, Odisha, where indigenous

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techniques reduce labour drudgery and improve ergonomic efficiency, demonstrates how traditional ecological knowledge can enhance both social and environmental outcomes (Yadav, Singh, Kumari *et al*., 2024). Forest provisioning and non-timber forest product (NTFP) economies among tribes of the Western Ghats also illustrate how cultural dependency on ecosystems yields practices of resource conservation and cyclical use (Frontiersin Ecology, 2023).

Despite this richness, mainstream CE scholarship shows a relative under-representation of empirical studies that deeply engage with indigenous or tribal communities, especially in the Indian context. Many CE studies focus on industrial, urban, policy, and technological interventions. Few explore how tribal communities historically embodied CE principles, or how those traditions are being maintained, transformed, or disrupted under modernization pressures. There is also limited work connecting such practices with policy, SDGs (especially SDG 12: Responsible Consumption and Production; SDG 15: Life on Land), and frameworks that can scale or integrate indigenous logics into wider sustainability agendas. While bibliometric studies have connected CE more broadly with SDGs (Pal *et al*., 2025), there remains a gap concerning how tribal knowledge can concretely inform CE models in rural, forested, or indigenous settings.

This study aims to address that gap by offering a qualitative case-analysis of documented traditional practices among Indian tribal communities that exemplify circular living. The novelty of this research lies in interpreting tribal practices not as peripheral or nostalgic but as living, well-established models of circular economy where zero-waste agriculture, communal ownership, regenerative ecological management, waste minimization, and sharing are integral rather than appended. By systematically synthesizing multiple case studies from ethnographies, development reports, and environmental research, we seek to articulate how the cyclical and sustainable systems operated by tribes can inform contemporary CE theory and policy.

The rationale is two-fold: first, to give scholarly visibility to indigenous practices that have often been marginalized or undervalued in academic CE and sustainability discourse; second, to extract principles and models that policymakers and environmental planners can meaningfully integrate into modern sustainability frameworks, particularly in India but also more broadly in Global South contexts.

Research Objectives

1. To identify and analyze key traditional practices among Indian tribal communities that reflect core principles of the circular economy (e.g., reuse, repair, regeneration, sharing, zero waste).
2. To understand the knowledge frameworks, governance structures, and social norms that sustain these practices.
3. To examine the challenges and pressures (environmental, economic, social, policy) that affect the continuity or transformation of these practices.
4. To derive policy-relevant insights for integrating indigenous circular models into present-day sustainability and resource-management frameworks in India, aligning with SDG 12 and SDG 15.

By fulfilling these objectives, this study contributes to both theory and practice. Theoretically by expanding CE models to better account for indigenous wisdom and non-industrial resource cycles; practically by offering grounded recommendations for policy design, community resilience, and ecological harmony that are culturally appropriate.

LITERATURE REVIEW

The recent literature (2020–2025) collectively underscores that Indigenous and local knowledge systems embody critical principles relevant to circularity notably stewardship, reuse, regenerative agriculture, and communal governance but the majority of CE research remains focused on industrial, urban, and technological interventions (and on high-income country case studies). Several high-quality studies demonstrate the policy relevance of ancestral circular practices (e.g., Hawai‘i, Western Ghats), the practical value of TEK for restoration and resilience, and the governance advantages of community-based natural resource management. However, there is a persistent gap: few studies synthesize multiple Indian tribal case studies to explicitly frame these practices as operational models of the circular economy or to translate them into scalable, culturally sensitive policy guidelines. This paper fills that gap by systematically synthesizing documented tribal practices across Indian regions, mapping the knowledge frameworks and governance institutions that sustain circular practices, and offering policy-relevant principles that align with SDG 12 and SDG 15. In doing so, it moves indigenous practices from being treated as isolated examples to being recognised as living models that can enrich contemporary CE theory and practice.

Author(s) & Year	Study Title / Focus	Context / Region	Key Findings	Research Gaps / Limitations	Relevance to Present Study
Beamer, K. (2023)	Island and Indigenous systems of circularity: how	Hawai‘i / Pacific Island	Shows how ancestral Indigenous worldviews (e.g., aloha ‘āina)	Focuses on Hawai‘i; limited comparative cross-regional empirical	Demonstrates methodological model: treat indigenous systems

	Hawai'i's ancestral circular economy informs policy conceptual & empirical analysis	Indigenous systems	operationalize circularity (resource stewardship, reciprocity, custodial governance) and how these can inform modern CE policy design. Emphasizes social and cultural dimensions beyond material flows.	cases. Less attention to South Asian / Indian tribal systems.	as policy-relevant CE models; supports the paper's comparative, cross-case synthesis aim.
Souther, S. *et al*., (2023)	Integrating Traditional Ecological Knowledge (TEK) into U.S. land management — review & case synthesis	U.S. public lands / TEK literature	TEK has measurable value for restoration, conservation and resilience; practical integration into management requires trust-building and legal recognition. Provides frameworks for operationalizing TEK in governance.	Largely U.S.-centric; highlights institutional barriers but not circular economy framing explicitly.	Identifies governance and recognition barriers that are likely echoed in Indian tribal contexts; informs the present study's focus on governance structures sustaining circular practices.
Fariss, B., *et al*., (2022)	Catalyzing success in community-based conservation: human well-being and environmental outcomes — meta-analysis of CBC projects	Global (meta-analysis of 128 projects)	Majority of CBC projects show positive social and environmental outcomes when local institutions and knowledge are central; CB governance improves sustainability outcomes.	Meta-analysis aggregates diverse cases; lacks focused synthesis on CE concepts or on Indian tribal case clusters.	Provides empirical evidence that community governance contributes to sustainable outcomes — supports analysis linking tribal institutions with circularity.
Benyei, P. (2022)	*I*ndigenous and Local Knowledge's Role in Social Movements & CBNRM — qualitative meta-analysis	Global case studies	ILK underpins community resistance and resource governance; social movements mobilize ILK to protect CBNRM systems. Shows political/ social drivers of knowledge persistence.	Emphasizes social movement dynamics; limited material-flow or technical CE framing.	Highlights political/social dimensions and resilience of ILK — useful for interpreting how tribal circular practices persist or transform under external pressures.
Balasubramanian, M., *et al*., (2023)	Valuing ecosystem services using IPLC perspectives in the Western Ghats	Western Ghats, India	Demonstrates non-monetary and cultural values of ecosystem services as defined by Indigenous Peoples and Local Communities (IPLCs). Argues for IPLC integration in valuation and policy.	Focuses on valuation methods; does not build a CE model from traditional practices. Sample limited to Western Ghats region.	Supplies India-specific evidence of IPLC value systems and governance— directly relevant to framing Indian tribal circular practices and informing policy translation.
Sangha, K.K. (2024)	Reshaping conservation: Soliga Adivasi and coexistence with tigers — case study	Soliga Adivasi, Western Ghats, India	Documents indigenous co-management, customary rules, and resource-use practices that sustain biodiversity; shows	Single-community case; limited explicit mapping to CE terminology.	Offers a robust Indian tribal case demonstrating how customary norms operationalize cyclical resource use a primary candidate for

			local norms embed regenerative use.		inclusion in the paper's case synthesis.
Tehrani, Y.A.F. (2025)	Integrating TEK into circular economy frameworks for remote/Indigenous contexts	Remote / northern rural & Indigenous communities (Canada)	Proposes frameworks for embedding TEK into CE design for consumer durable goods and remote contexts; stresses culturally-appropriate circular strategies and local repair/ reuse networks.	New framework but geographically different; empirical tests remain limited.	Conceptual and methodological template for integrating TEK and CE in remote/tribal settings; informs adaptation to Indian tribal case analysis.
Systematic review (2022)	Integration of Indigenous & local knowledge in sustainability education / governance — systematic review	Global literature review	Summarizes adoption patterns in education and practice; calls for epistemic justice, inclusive methods, and practical co-production.	Many studies focus on pedagogy/education rather than CE policy or material-flow analysis.	Reinforces the need for epistemic inclusion supports paper's rationale to treat tribal practices as knowledge systems to inform CE models and policy.
Ghatak, A. (2024)	Millets for a sustainable future: role of traditional crops in food systems.	India & global evidence on millets	Highlights millets' low-input circular agriculture practices (crop diversity, residue reuse); positions traditional crops as climate-resilient and resource-efficient.	Crop-centric review; does not deeply explore community governance or broader CE framing.	Provides agricultural examples (zero/low-waste, residue recycling) that operationalize circular principles in tribal farming systems useful empirical illustration.
Seth, U. (2024/25)	Millets in India: historical significance, cultural dimensions and sustainability	India (ethnic/ tribal food systems)	Documents cultural embedding of millets and links to nutritional security, local markets, and traditional recipes; highlights conservation of crop varieties through tribal custodianship.	Cultural focus; limited explicit CE theoretical mapping.	Strengthens the evidence base for Agro-circular practices among Indian tribes and provides culturally grounded examples for the paper's case analysis.

MATERIALS AND METHODS

Research Design

This study adopts a qualitative interpretive research design focused on secondary case analysis to explore how indigenous wisdom and traditional ecological knowledge (TEK) among Indian tribal communities reflect the principles of the circular economy (CE). The approach relies on *document-based qualitative inquiry*, emphasizing interpretation and synthesis of existing empirical and ethnographic evidence. Such a design is appropriate for uncovering cultural, ecological, and systemic dimensions of sustainability that are not easily quantifiable but are richly embedded within indigenous traditions (Creswell & Poth, 2018). The interpretive paradigm allows examination of how local practices, social norms, and community values form cyclical resource-use systems aligning with modern CE frameworks. Through systematic content analysis and cross-case comparison, the study aims to derive conceptual and practical insights from existing documentation rather than conducting fieldwork or primary data collection.

Data Sources

The research utilized secondary qualitative data drawn from multiple peer-reviewed, governmental, and institutional sources between 2018 and 2025. Data were obtained from:

Academic Publications:

Empirical and conceptual studies published in high-impact journals such as Journal of Cleaner Production, Ecological Economics, Sustainability, Resources, Conservation & Recycling, and Environmental Science & Policy.

Government and NGO Reports:

Documents from the Ministry of Tribal Affairs (GoI), the National Innovation Foundation, and the Forest Rights Act (FRA) implementation records.

Case Documentation:

Reports and studies documenting sustainable tribal practices across India from institutions such as the Centre for Science and Environment (CSE), and the Indian Council of Forestry Research and Education (ICFRE).

Ethnographic and Environmental Studies:

Secondary ethnographic literature and field reports highlighting indigenous livelihood systems, resource management, and community governance. These diverse sources provided comprehensive evidence on tribal practices across regions, allowing triangulation and validation through cross-comparison.

Case Selection:

A purposive sampling strategy was adopted to select representative cases demonstrating established indigenous sustainability models that align with CE principles. Five cases were identified based on documented evidence, ecological diversity, and cultural richness:

Case	Region	Core Practice	Circular Economy Aspect
Pachgaon, Maharashtra	Western Ghats	Bamboo-based circular economy under forest rights	Resource regeneration and livelihood circularity
Nungbi, Manipur	Northeast India	Traditional black pottery using local clay and natural dyes	Sustainable material use and waste minimization
Kendu Leaf Collection, Odisha	Eastern India	Traditional forest resource collection for bidi making	Regulated resource use and community-based management
Mahua Tree Revival, Chhattisgarh	Central India	Revival of Mahua-based products for food, oil, and liquor	Ecological restoration and local value addition
Adilabad District, Telangana	Central India	Weekly tribal markets as local circular trade systems	Localized exchange and zero-waste trading

Each case was selected for its documentation richness and relevance to CE principles such as reuse, recycling, regeneration, and collective ownership.

Analytical Framework:

The study applied a thematic content analysis following the six-phase process outlined by Braun and Clarke (2021): familiarization, coding, theme generation, reviewing, defining, and reporting. The coding process focused on identifying recurring patterns of circularity, regeneration, and sustainability across the selected cases.

To ensure conceptual clarity, the findings were mapped against the Ellen MacArthur Foundation's Circular Economy Framework (regenerate, share, optimize, loop, virtualize, and exchange). This framework served as an analytical lens for interpreting indigenous practices in relation to CE principles. Additionally, the Indigenous Knowledge Systems (IKS) lens was used to contextualize cultural and ethical dimensions, focusing on reciprocity, collective ownership, and intergenerational stewardship. By merging both frameworks, the analysis captured how indigenous ecological models naturally integrate circular principles without external technological inputs.

Data Analysis Procedure:

The analytical process followed a structured, interpretive approach comprising thematic categorization, cross-case comparison, and conceptual synthesis. Initially, data drawn from secondary sources were systematically coded into four overarching meta-themes: resource circulation and reuse, community governance and equity, ecological regeneration and biodiversity, and knowledge transmission and adaptation. Each case was then examined individually and comparatively to identify convergent and divergent sustainability patterns across indigenous practices. The resulting insights were synthesized to develop a conceptual framework linking Indigenous Knowledge Systems (IKS) with the Circular Economy (CE), demonstrating how tribal practices operate as closed-loop systems at both ecological and socio-economic levels. Reliability was ensured through consistent inclusion criteria and transparent documentation, while construct validity was strengthened by triangulating multiple reports and peer-reviewed studies for each case. Ethical research principles were strictly followed by acknowledging community-originated knowledge and avoiding the use of proprietary or culturally sensitive data; as the study relied solely on secondary sources, no human subjects or field interventions were involved, and institutional ethics approval was not required. Indigenous intellectual property and cultural heritage were respected in accordance with the UN Declaration on the Rights of Indigenous Peoples (UNDRIP, 2007). Overall, this integrated analysis situates Indian tribal knowledge systems within the CE paradigm, offering a culturally grounded pathway for sustainable development aligned with SDG 12 (Responsible

Consumption and Production) and SDG 15 (Life on Land).

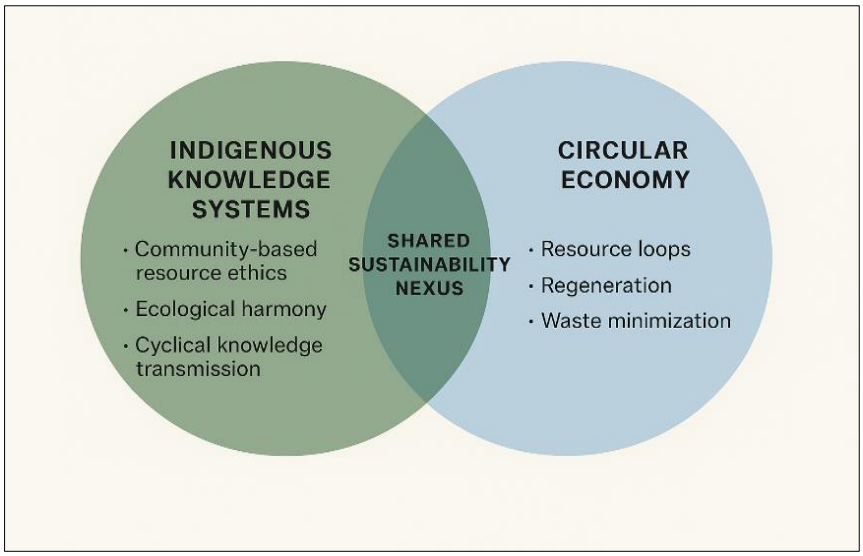

Figure 1: Developed Venni Diagram

RESULTS AND DISCUSSION

Case 1: Pachgaon, Maharashtra – Bamboo-Based Circular Economy.

Pachgaon, a *Gond* tribal village in Gadchiroli district, Maharashtra, serves as a compelling exemplar of a forest-based circular economy grounded in community forest rights. After securing legal recognition of Community Forest Rights under the Forest Rights Act, 2006, in 2012, the villagers took collective control over 1,006 hectares of bamboo-dominated forests. This legal empowerment enabled them to institute sustainable resource harvesting regimes, equitable benefit sharing, and ecological regeneration practices (Ideas for India, 2022; Azim Premji University, n.d.).

A core sustainability practice is the rotational harvesting of bamboo: the forest is divided into zones, and cutting is undertaken in one zone at a time, on a three-year cycle to allow for regeneration. Harvesting is halted during monsoon months (roughly June to October), both to allow ecological recovery and to align with traditional ecological calendars. Villagers use only matured bamboo that is age-appropriate (typically three years old), leaving sufficient culms unharvested to maintain forest structure and biodiversity. (Kothari, A. (2019).

Waste from bamboo processing such as bark, leaves and off-cuts is reused locally: leaf litter and bark are composted or used for fuel, minimizing waste and closing material loops. The community also adds value via product diversification (e.g., furniture, handicrafts), and is making moves toward biochar and other value-added processing of non-timber forest produce (NTFPs) stored in a village depot (Cultural Survival. (2025).

Social circularity is strong in Pachgaon. Gender-inclusive labour arrangements mean women receive equal wages as men for bamboo harvesting and other tasks. Also, decision-making and governance are highly participatory: the Gram Sabha sets rules including quotas per individual (e.g. a limit of 50 bamboos per person in certain age groups per day) to ensure equity and prevent overharvesting. These wages are disbursed weekly, and a portion is saved (retained by Gram Sabha) for off-season support when bamboo cutting is not possible. Economically, Pachgaon has used profits from bamboo and associated enterprises to fund local infrastructure (storage depots, offices, processing units), education, housing, and to reduce distress migration. For example, after first sales in 2013 (8,100 bamboo bundles raising ~INR 700,000), revenues doubled the next year (~INR 2.7 million), and over time the income has provided stable livelihoods even when external shocks (e.g. COVID-19) lowered market demand.

Ecologically, forest conservation has improved: the ban or voluntary reduction of tendu collection, restrained use of mahua flowers for alcohol, fire control, guarding against illegal extraction, and periodic mapping and supervision by volunteers have led to better forest regeneration and biodiversity protection. Overall, Pachgaon illustrates a multi-loop circular system: resource input is minimized by sustainable harvesting; outputs are reintegrated via composting, local reuse, value addition; social and financial returns are reinvested locally; governance ensures ecological resilience and social equity. The case demonstrates how traditional ecological knowledge, institutional rights, and community governance can together generate a working circular economy embedded in indigenous practice.

Table 1: Comparison of Circular Economy Model and Its Traces in Pachgaon Village (Maharashtra)

Circular Economy Principle / Model Element	Description in Circular Economy Framework	Traces Observed in Pachgaon Case	Illustrative Outcome
1. Resource Regeneration & Sustainable Extraction	Resources are harvested without depleting ecosystems; focus on renewable, regenerative sources.	Bamboo harvested rotationally every three years; only mature culms are cut, allowing natural regeneration of forests.	Maintained bamboo productivity and biodiversity across 1,006 hectares of community forest.
2. Waste Minimization & Zero-Waste Loops	Waste from production is minimized or reintegrated into the system through reuse, recycling, or composting.	Bamboo leaves and bark reused as compost and biofuel; leftover materials utilized for craft products and local energy needs.	Closed-loop production cycle and reduction in environmental waste.
3. Local Value Creation & Economic Reinvestment	Economic value generated from resource use is retained locally to strengthen regional resilience.	Profits from bamboo sales reinvested in education, health, infrastructure, and local enterprise development.	Circulation of wealth within the community, leading to self-sustained rural development.
4. Product Life Extension / Value Addition	Extending product life through repair, redesign, or upcycling; creating multiple value loops.	Bamboo processed into multiple products—handicrafts, furniture, and potential biochar—extending material life and diversifying income.	Multi-stream livelihood creation and higher economic returns from the same raw material.
5. Social Circularity & Inclusive Participation	Ensuring equitable participation across genders and social groups in production and governance.	Women actively participate in harvesting, processing, and decision-making; equal wage structures implemented.	Strengthened social equity and empowerment of marginalized groups.
6. Knowledge Sharing & Intergenerational Learning	Transfer of sustainable practices, traditional ecological knowledge, and community values across generations.	Elders teach sustainable harvesting methods, forest monitoring, and ecological rituals to younger members.	Continuity of indigenous ecological wisdom and cultural preservation.
7. Governance & Feedback Mechanisms	Local governance structures that monitor, regulate, and adapt system efficiency.	Gram Sabha (village council) enforces rotational harvesting, equitable distribution, and ecological monitoring.	Transparent, community-led management ensuring long-term sustainability.
8. Systemic Integration of Ecology, Economy, and Society	Interconnected systems where natural, social, and financial cycles reinforce each other.	Ecological (forest regeneration), social (gender equity), and economic (local reinvestment) cycles are integrated seamlessly.	A holistic circular economy model embedded in local socio-ecological systems.

Case 2: Nungbi, Manipur – Traditional Black Pottery.

Nungbi Khullen, in the Ukhrul district of Manipur, is the home of the Tangkhul Naga tribe's centuries-old artisanal tradition of black pottery, locally known as *Longpi Hampai* or *Longpi Ham*. This craft offers a striking example of low-carbon, circular craftsmanship rooted in indigenous resource management, ancestral techniques, and sustainable lifecycles. Drawing primarily on the study *"The Making of Nungbi Ham: A Study of Nungbi Pottery of Manipur, India" (Humankind, 2015)* along with reports from cultural heritage preservation projects, this case reveals how material recirculation, waste minimization, craftsmanship lifecycles, and cultural preservation are integrally combined in this village. The raw materials for Longpi pottery are serpentine stone (also known as serpentinite) and a special brown clay, both of which are sourced locally in and around Nungbi Khullen and neighbouring Longpi Kajui. The serpentine stone is hand-picked, broken down manually into finer particles (by pounding or grinding), then mixed with clay and water to form a workable paste. Notably, no potter's wheel or mechanized shaping tools are used; instead, artisans shape each vessel entirely by hand, often using beaters or moulds to refine walls, thickness, and form. Broken or defective pottery pieces are often crushed and reused as part of new paste mixtures, thereby closing the loop on material use and reducing waste. This practice of recycling stone-and-clay paste helps maintain consistency in material properties, while avoiding resource loss. (Though the detailed proportions and yields are less frequently documented, the recirculation of broken fragments is a recognized practice in this craft's tradition.)

The firing process is likewise modest in its environmental footprint: biomass (wood, local fuel) is used rather than fossil-fuelled kilns, and firing is managed using simple kilns or bonfires; drying is done in the open sun; no synthetic chemical additives or glazes are employed. The final black metallic sheen is often achieved by polishing the hot pottery with local leaves such as *Pasania pachiphylla* ("Chiron Na / Machithing" in local parlance) immediately after firing, adding lustre via natural compounds rather than chemical glazes. Economically, about 200 families in Nungbi are reported to be directly supported by this black pottery craft, many of them depending on it as either primary or significant supplementary income. There has been growing national demand for these potteries both for functional kitchenware (pots, utensils, kettles) and decorative items and increased interest from urban, ecologically conscious consumers in India (Delhi, Mumbai etc.). Such demand has stimulated cooperative/group-based production forms. Artisans have expressed a need for better infrastructure (e.g. work sheds that allow production in rainy season) to smooth production cycles.

Culturally, the craft is more than livelihood: it is deeply embedded in Tangkhul identity. The skills and practice are passed down intergenerationally, keeping alive ancestral myths, symbolic embodiments, and ritual functions (e.g. pots used in festivals or ceremonial cooking). Authorities local to cultural heritage (such as the ICH-Scheme project for *Longpi or Loree Black Stone Pottery*) have recognized the craft's importance both as heritage and as economically viable traditional industry.

Table 2: Comparison of Circular Economy Model and Its Traces in Nungbi (Longpi Black Pottery), Manipur

Circular Economy Principle / Model Element	Description in Circular Economy Framework	Traces Observed in Nungbi Black Pottery Case	Illustrative Outcome / Impact
1. Resource Regeneration & Local Sourcing	Sustainable extraction and use of renewable, locally available resources to reduce dependence on external inputs.	Artisans use locally sourced serpentine stone and clay from nearby hills, ensuring minimal transport and ecological disruption.	Reduction in resource depletion, preservation of local geological ecosystem, and low carbon footprint.
2. Waste Minimization & Closed-Loop Material Use	Ensuring all waste materials are reused, recycled, or reintegrated into production.	Broken or defective pots are ground into fine powder and mixed with new clay–stone paste for the next batch of pottery.	Zero-waste production cycle and minimized material loss.
3. Low-Carbon Production & Energy Efficiency	Use of low-energy or renewable energy sources instead of fossil fuels; minimizing emissions.	Pottery is fired using biomass (wood, leaves) and sun-dried; no industrial kiln or fossil-fuel-based equipment used.	Maintains a low-carbon production process aligned with sustainable energy principles.
4. Product Life Extension / Durability	Designing durable, long-lasting, and multifunctional products to reduce consumption frequency.	Black pottery items are strong, heat-resistant, and suitable for both cooking and decorative use.	Longer product life cycle and reduced consumption turnover.
5. Value Addition through Craftsmanship	Enhancing material value through creative redesign, handcrafting, or upcycling.	Handmade shaping, polishing with natural leaves (*Pasania pachiphylla*) for sheen, and unique aesthetics enhance value without chemical additives.	Increased product marketability while maintaining ecological integrity.
6. Social Circularity & Cooperative Production	Promoting inclusive participation and local economic loops through community-based production.	Approximately 200 Tangkhul Naga families involved; production cooperatives ensure shared profits and equitable labor distribution.	Economic reinvestment within the village and collective livelihood security.
7. Cultural Continuity as Sustainability Mechanism	Using cultural traditions to sustain sustainable behaviors and intergenerational learning.	Pottery techniques, rituals, and symbolic meanings are passed down orally and through apprenticeship.	Preservation of indigenous knowledge and sustainable cultural heritage.
8. Governance & Community-Based Resource Management	Local control and regulation of resource extraction and production processes.	Village elders and artisan groups collectively decide on clay and stone extraction zones and craft production schedules.	Ensures long-term ecological stewardship and self-regulated resource use.
9. Market Adaptation & Economic Circularity	Creating sustainable demand and reinvestment cycles by adapting traditional products to modern markets.	Growing demand from eco-conscious consumers and craft exhibitions provides new market avenues.	Strengthened rural economy and continuity of indigenous enterprise within modern green markets.

Case 3: Kendu Leaf Collection, Odisha – Traditional Resource Use.

The kendu leaf system in Odisha, especially in the Jeypore division and the greater Koraput region, manifests a well-established renewable resource economy deeply embedded in community welfare, ecologically mindful harvesting, and cooperative governance. Drawing upon research such as *"Livelihood dependence and marketing of Kendu leaves in Sambalpur kendu leaf circle"* (Bagh, 2018), government documents of the Odisha Kendu Leaf Organisation, and recent journalistic and policy reports, this case exemplifies how traditional systems continue to trace circular economy principles in practice. Kendu leaves (locally called "KL") are a naturally renewable non-timber forest product (NTFP) that regenerate annually. The Odisha Kendu Leaf Organisation (KL Organisation) manages the resource through practices like *bush cutting (coppicing)* in February–March, which allows leaves to regrow on new shoots, and then waiting about 45–50 days before plucking. This cyclical extraction, done without clear felling, ensures the shrubs regenerate, preserving ecological integrity, Community-led Cooperatives, Employment, and Local Value Retention.

Thousands of tribal households depend on kendu leaf collection as a major livelihood source, particularly in the lean agricultural season. The system provides employment (mandays) for pluckers, binders, and seasonal workers. For example, in 2021, over 766,000 people in Odisha were involved in plucking and collecting leaves, yielding large volumes (over 1.25 billion kerries) of KL, and generating significant income for forest-dwelling communities. Community forest bodies or Gram Sabhas in many blocks (e.g., Boipariguda in Koraput) have formed collectives or Mahasanghs to better manage collects, pricing, transportation, and equitable benefit sharing. After collection, materials that are not fit for the highest quality grades defective leaves, over-mature or mildly damaged leaves are sorted out. The system also employs composting of leaf waste, and stalks or residual parts are used as natural mulch. These are not always the highest-profile features in published studies but are reported in official documents of KL Working and in qualitative interviews with pluckers, showing that waste-to-soil flows are part of routine practice.

Despite its strengths, the kendu leaf economy faces policy challenges. Issues around taxation (GST), regulatory delays in recognizing community rights under the Forest Rights Act, required permissions for sale and transport, and infrastructure bottlenecks (e.g. distance to collection centres or phadis) limit benefit flows to collectors. For example, delays or lack of collection infrastructure can lead to leaf spoilage, which directly causes loss of income.

Table 3: Comparison of Circular Economy Model and Its Traces in Kendu Leaf Collection System (Odisha)

Circular Economy Principle / Model Dimension	Description in Circular Economy Context	Traces in Kendu Leaf Collection System (Odisha)	Evidence of Circularity / Sustainability Outcome
1. Renewable Resource Management	Emphasizes use of naturally renewable materials with sustainable harvesting cycles.	Kendu leaves are collected seasonally under regulated quotas to ensure forest regeneration and biodiversity preservation.	Maintains ecological balance; ensures continuous annual yield without overexploitation.
2. Waste-to-Resource Conversion	Encourages transformation of waste into valuable inputs for natural or industrial cycles.	Residual leaf waste is composted; stalks and stems are reused as organic mulch in nearby farmlands.	Promotes soil enrichment, reduces dependency on synthetic fertilizers, and prevents landfill accumulation.
3. Local Value Retention and Employment	Keeps economic benefits within local communities through cooperative or decentralized systems.	Tribal cooperatives manage collection, pricing, and employment distribution, ensuring community ownership.	Sustains thousands of livelihoods; retains economic value within tribal settlements instead of externalizing profit.
4. Social Circularity and Governance	Embeds equity, shared governance, and community participation in production cycles.	Forest cooperatives under the Forest Rights Act democratically allocate resources and share profits among members.	Enhances social cohesion, equity, and accountability, reinforcing inclusive economic models.
5. Resource Efficiency through Traditional Knowledge	Utilizes indigenous methods that optimize resources and minimize ecological footprint.	Local knowledge of leaf selection, drying, and grading ensures minimal waste and high-quality output.	Reduces energy and material consumption while preserving traditional craftsmanship.
6. Economic Resilience and Adaptive Systems	Builds self-sustaining, adaptive economies that respond to ecological and policy changes.	Despite taxation and policy challenges, local cooperatives adapt pricing strategies and diversify livelihoods.	Demonstrates resilience and adaptive capacity against external economic pressures.

Case 4: Mahua Tree Revival, Chhattisgarh – Ecological and Economic Sustainability.

In the Manendragarh Forest Division of Chhattisgarh, the *Mahua Bachao Abhiyan* (Save Mahua Campaign) is a recent and significant initiative that illustrates how tribal communities, local governance structures, and forest departments collaborate to restore ecological cycles, socio-economic stability, and cultural heritage through the revival of *Madhuca longifolia* (Mahua) trees. The campaign revives barren *gothans,* former cattle shelters or unused communal land and empty field peripheries by planting large numbers of Mahua saplings, protecting them via tree guards, and involving gram panchayats and self-help groups. One critical ecological trace in this model is regenerative forestry: Mahua is a perennial keystone species native to the region, with long life (up to ~60 years), and multi-use functions including flowers, seeds, oil, medicinal bark, and other parts. The initiative counters previous unsustainable practices such as burning land during flower-collection season or harvesting all seeds (which limits natural propagation). By planting 1.12 lakh (112,000) saplings in gothans, field edges, and community points, and distributing tens of thousands of tree guards, the program ensures not only regeneration but also protection and survival of young trees. From an economic standpoint, the Mahua revival supports tribal livelihoods heavily reliant on it. In villages like Amaad (Gariaband district), families with Mahua trees gather and sell flowers and seeds during the Mahua season, generating significant income (some families harvesting 20-25 quintals from 50-60 trees). The presence of mature Mahua trees assures recurring seasonal income, thus reducing dependence on external wage labour or migration in lean seasons.

Another circularity element is waste reuse and nutrient cycling: Mahua flower residues (after oil or liquor preparation etc.) are reused as compost or fuel by local households. Although detailed peer-reviewed measurements of nutrient return are not yet widely published, community reports indicate broad adoption of residue composting. Protection of soil (by preventing erosion), moisture retention, and use of leaf litter or fallen flowers for soil enrichment are part of local ecological practices. Finally, revenue reinvestment and community participation are central. The Forest Department, local gram panchayats, and SHGs jointly manage sapling planting, caring for the young trees, guarding them, and ensuring yields are harvested sustainably. Proceeds from the Mahua harvest feed into local wellbeing household incomes, community welfare, and reinvesting in natural resource stewardship (tree guard purchase, fencing, maintenance). The sense of ownership among villages, when coupled with traditional reverence for Mahua as *"Kalpavriksha"*, reinforces ecological stewardship.

This case highlights a multi-loop system of circular economy in which ecological, economic, and cultural dimensions are intertwined: regeneration of forest stocks, sustainable harvest, reuse of biological residues, and reinvestment of benefits into ecosystem services and local governance. It provides a model for how restoration of degraded lands, when tied with traditional knowledge and community governance, can serve as a durable path toward sustainability and resilience.

Table 4: Comparison of Circular Economy Model and Its Traces in Mahua Tree Revival (Chhattisgarh)

Circular Economy Principle / Model Dimension	Description in CE Context	Traces Observed in Mahua Tree Revival Case	Illustrative Outcome / Sustainability Impact
1. Regenerative Resource Management	Ensures natural resources are replenished and ecosystems restored.	Planting and protecting Mahua saplings in degraded gothans; perennial growth ensures ongoing ecological regeneration.	Restoration of degraded lands; sustained supply of Mahua products over decades.
2. Waste Reuse & Nutrient Cycling	Residuals or by-products are reintegrated into natural or production cycles.	Mahua flower residues and fallen leaves are composted or used as fuel, enriching soil and reducing waste.	Improved soil fertility and reduction in external input dependency.
3. Economic Reinvestment / Local Value Retention	Profits and revenues are reinvested locally to strengthen community and ecosystem resilience.	Revenue from Mahua-based products is reinvested in village development, tree protection, and local governance.	Strengthened local economy and sustainable community-based natural resource management.
4. Community Participation & Governance	Inclusive, participatory management ensures equitable benefit-sharing and sustainable practices.	Gram panchayats and self-help groups manage planting, maintenance, and harvest; collective decision-making.	Enhances social cohesion, stewardship ethics, and adherence to sustainable harvesting protocols.
5. Multi-Functional Use of Resources	Maximizes value by using products across ecological, economic, and cultural domains.	Mahua provides food, oil, liquor, and medicine; flowers, seeds, and other parts are utilized in multiple value chains.	Reduces pressure on alternative resources and strengthens cultural continuity.

6. Ecological Stewardship & Adaptive Management	Integrates environmental monitoring and adaptive practices to maintain ecosystem health.	Community ensures saplings are protected, seasonal collection is regulated, and soil enrichment occurs naturally.	Long-term ecosystem health, prevention of land degradation, and resilience to climate variability.
7. Cultural Circularity & Knowledge Transmission	Traditional knowledge and cultural practices reinforce sustainable resource use.	Mahua is embedded in local festivals, rituals, and intergenerational knowledge of sustainable harvest and use.	Continuity of ecological knowledge and cultural identity linked to sustainability.

Case 5: Adilabad District, Telangana – Weekly Tribal Markets as Local Circular Trade Systems.

In the Adilabad district of Telangana, weekly tribal markets, locally known as 'Shanthas,' serve as vital hubs for the exchange of seeds, grains, vegetables, and handmade goods among tribal communities. These markets are integral to the local economy, facilitating direct trade between producers and consumers, thereby reducing reliance on external supply chains and maintaining localized material loops. A study by Desai (2016) highlights that these markets are significant in size, attracting a large number of sellers and buyers. Tribal people engage in buying and selling commodities, and the presence of Girijan Cooperative Corporation (GCC) depots in these markets could further support tribal communities by providing access to essential goods. Unused produce in these markets is often composted or exchanged, ensuring minimal food waste. This practice aligns with sustainable waste management principles, contributing to soil enrichment and reducing environmental impact.

The social structure of these markets fosters trust-based credit systems and skill-sharing among community members. Such reciprocal trade networks ensure equitable distribution of goods and services, reinforcing social and economic symbiosis within the tribal economy. In conclusion, the weekly tribal markets in Adilabad exemplify localized circular trade systems that promote sustainability through waste minimization, equitable distribution, and community-based economic practices.

Table 5: Comparison of Circular Economy Model and Its Traces in Adilabad Weekly Tribal Markets, Telangana

Circular Economy Principle / Model Dimension	**Description in CE Context**	**Traces Observed in Adilabad Tribal Markets**	**Illustrative Outcome / Sustainability Impact**
1. Localized Production–Consumption Loops	Encourages consumption within the local community to reduce supply chain length.	Farmers and artisans sell and exchange goods directly in weekly markets, minimizing reliance on external markets.	Reduced transportation emissions and strengthened local economy.
2. Waste Minimization & Resource Recirculation	Ensures unused or excess products are reintegrated or repurposed.	Unsold produce is composted, exchanged, or reused within the community.	Zero food waste, improved soil fertility, and circular nutrient flows.
3. Minimal Transportation Footprint	Reduces carbon emissions by shortening the distance between production and consumption.	Localized weekly markets reduce the need for long-distance transport of goods.	Lower energy use, smaller carbon footprint, and reduced environmental impact.
4. Social Circularity & Reciprocal Networks	Promotes trust-based social exchanges, credit systems, and skill sharing within the community.	Market participants rely on reciprocal trade, informal credit, and knowledge sharing.	Strengthened social cohesion, equitable access to goods, and resilience of local economy.
5. Multi-functional Use & Value Retention	Products are utilized across different purposes or transformed to maximize value.	Seeds, grains, and handmade goods serve both consumption and trade purposes.	Enhanced economic utility and sustainable livelihoods.
6. Community Governance & Inclusion	Local communities manage economic and resource exchanges collectively.	Markets are organized and regulated by tribal communities with informal governance structures.	Fair distribution of benefits and community-driven decision-making.

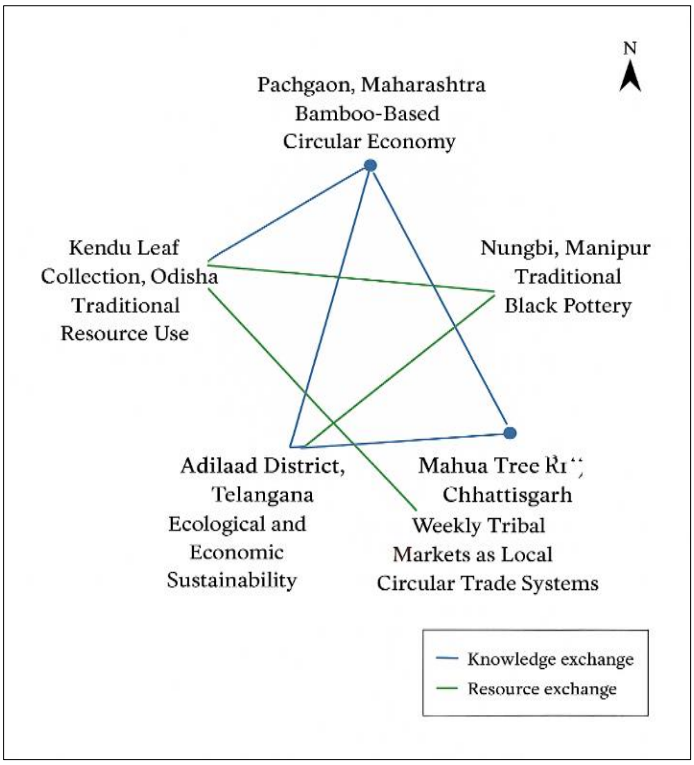

Figure 2: Network Map of Resources and Knowledge Exchange among Indigenous Circular Economy Communities in India

The network map illustrates an interconnected ecosystem of Indigenous Circular Economy practices across five tribal communities in India, each representing a distinct yet complementary sustainability model. Pachgaon emphasizes bamboo-based regeneration, Nungbi sustains traditional black pottery, Odisha's kendu leaf system reflects forest stewardship, Chhattisgarh's mahua revival integrates ecology with livelihoods, and Adilabad promotes localized circular trade through weekly markets. Blue linkages depict knowledge exchange pathways, showing how ecological wisdom and craft-based innovations circulate across regions. Green linkages represent resource flows, highlighting material interdependence among forest-based economies. The radial, non-hierarchical structure reflects the cooperative nature of indigenous learning and exchange systems. Collectively, the map reveals a decentralized model of circularity driven by reciprocity, resilience, and ecological ethics.

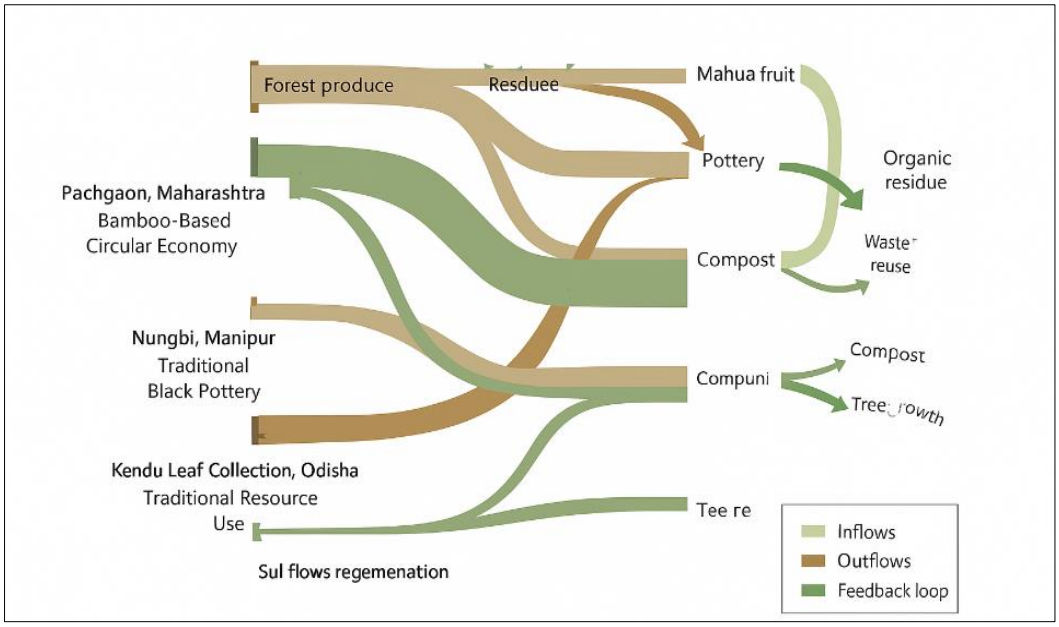

Figure 3: Sankey Diagram of Material Flows in Five Tribal Systems

The Sankey diagram depicts dynamic material flow systems operating within five Indigenous Circular Economy communities in India. It illustrates how forest produce, biomass, soil inputs, and craft materials circulate through processes such as harvesting, crafting, trading, composting, and regeneration. Flow thickness indicates the relative importance of each material stream, highlighting dominant pathways within the systems. Green feedback loops emphasize regenerative cycles, where waste is reintegrated into ecological processes to restore soil fertility and forest health. Brown and beige flows represent economic and material outputs, including finished goods, livelihoods, and reused by-products. The visualization underscores the closed-loop nature of indigenous economies, where waste functions as a productive resource. Overall, the diagram reveals a decentralized yet integrated sustainability network rooted in traditional ecological knowledge and circular resource governance.

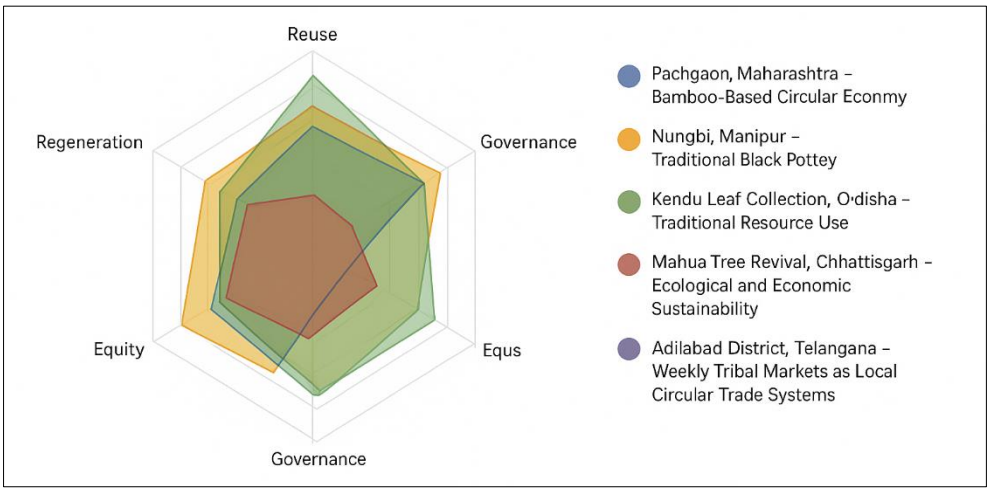

Figure 4: Comparative Circularity Radar Chart of Indigenous Circular Economy System

The comparative circularity radar chart presents the multidimensional performance of five Indigenous Circular Economy systems across key indicators of reuse, regeneration, governance, equity, and knowledge transmission. Each community displays a distinct yet overlapping sustainability profile, reflecting context-specific strengths. Pachgaon and Mahua Tree Revival show strong balance across reuse and regeneration due to effective biomass cycling and ecological restoration practices. Nungbi stands out in knowledge transmission and equity, highlighting the cultural continuity embedded in traditional pottery systems. Kendu Leaf Collection demonstrates moderate, stable performance across all dimensions, indicating a focused but less diversified circular model. Adilabad excels in governance and equity through collective market mechanisms and reciprocal trade practices. Overall, the chart reveals shared foundations of indigenous circularity alongside adaptive regional variations, underscoring holistic, community-driven models of sustainable development.

Comparative Analysis Table: Traces of Circular Economy in Tribal Case Studies

Community / Case	Material Loop	Waste Reuse / Reduction	Regeneration / Renewal	Social Equity / Governance	Circularity Score (1–5)
Pachgaon (Maharashtra)	Bamboo harvesting & processing	Composting bamboo waste	Replanting & forest regeneration	Gender-inclusive management	5
Nungbi (Manipur)	Clay & serpentine mixture reuse	Zero-waste craft	Traditional resource continuity	Cooperative craft networks	4
Kendu Leaf (Odisha)	Seasonal leaf collection	Composting leaf residue	Natural regrowth	Cooperative management	4
Mahua (Chhattisgarh)	Flower–fruit–compost cycle	Reuse of residues	Tree planting & soil regeneration	Gram panchayat governance	5
Adilabad (Telangana)	Local barter and trade	Composting unsold produce	Community subsistence resilience	Informal trust-based economy	4

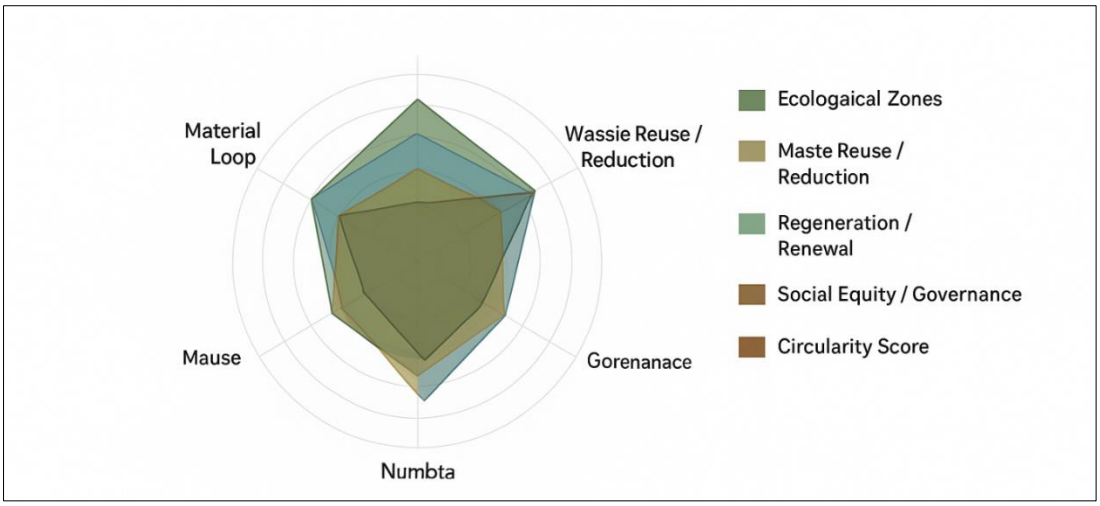

Figure 5: Comparative Circularity Performance of Five Indigenous Circular Economy Communities

Analytical Findings:

The qualitative synthesis of five tribal case studies indicates that indigenous communities in India have long practiced localized circular systems rooted in ecological reciprocity, minimal waste generation, and collective stewardship, closely aligning with contemporary circular economy (CE) principles. Cross-case analysis identifies four interrelated dimensions of indigenous circularity: resource circulation and zero-waste practices, community governance and collective ownership, ecological regeneration and biodiversity conservation, and knowledge transmission with cultural continuity. Community-managed initiatives such as bamboo enterprises in Pachgaon, localized market systems in Adilabad, and forest-based livelihoods involving kendu leaves and mahua illustrate closed-loop resource use, equitable distribution, and regenerative cycles. Governance through gram sabhas and forest committees reinforces social equity and environmental ethics, while intergenerational knowledge transfer sustains ecological wisdom. Collectively, these findings demonstrate that indigenous circular systems function as living, holistic models integrating material, social, and cultural dimensions, offering valuable, context-sensitive pathways for sustainable development aligned with SDG 12 and SDG 15.

Theoretical and Empirical Implications:

The findings of this study hold profound theoretical and empirical implications for the ongoing discourse on the Circular Economy (CE) and its adaptation within indigenous and community-based contexts. By introducing the concept of "Indigenous Circularity," this research broadens the epistemological and ontological foundations of CE, moving beyond industrial logics of efficiency and material recirculation to embrace a worldview grounded in ecological ethics, community governance, and cyclical knowledge transmission.

Theoretical Implications:

This study advances Circular Economy (CE) theory by introducing the concept of *Indigenous Circularity*, which situates circularity within a cultural–ecological framework rather than a purely economic or technological one. Unlike conventional CE models that emphasize industrial processes such as recycling, remanufacturing, and efficiency optimization, Indigenous Circularity conceptualizes sustainability as a lived, relational practice embedded in everyday community life. Rooted in indigenous worldviews, it foregrounds a non-anthropocentric ontology in which humans are integral to ecological systems, thereby reframing circularity from a managerial objective to an ethical and cultural mandate based on reciprocity, respect, and regeneration. The framework also contributes to the decolonization of sustainability theory by challenging the assumption that innovation flows exclusively from industrialized contexts, instead recognizing indigenous knowledge systems as legitimate and longstanding circular economies. By integrating community governance, collective ownership, and culturally embedded accountability into CE theory, the study expands systems thinking beyond production-centric models toward a culture-centric understanding of circularity. This theoretical shift enriches sustainability scholarship by positioning circular economy practices as socio-ecological ethics that sustain both ecosystems and cultural continuity across generations.

Empirical Implications:

Empirically, this study illustrates that indigenous and tribal communities operationalize circular economy (CE) principles through embedded social and ecological cycles rather than through industrial or technological interventions. Evidence from tribal markets, community seed systems, and forest-based livelihoods shows that circularity emerges organically from collective routines, customary norms, and ecological intuition. Localized exchange systems, such as weekly tribal markets, function as short-loop circular systems where goods circulate within

communities, waste is minimized through reuse and composting, and surplus distribution is guided by social norms instead of profit maximization. Forest-based practices further demonstrate regenerative cycles regulated by seasonal restrictions, cultural taboos, and communal oversight, ensuring resource renewal and biodiversity balance. These findings also challenge conventional metrics of circular success by highlighting qualitative outcomes such as social cohesion, ecological harmony, and ethical responsibility, alongside material efficiency. Collectively, the empirical evidence supports the need for bottom-up, culturally grounded CE policies and education frameworks that recognize indigenous knowledge transmission as a regenerative resource and position communities as active agents in sustainability transitions.

CONCLUSION

This study demonstrates that indigenous tribal communities across India have long practiced principles closely aligned with the contemporary circular economy, grounded in regeneration, minimal waste, and equitable resource distribution. The qualitative synthesis of case studies reveals that these communities have evolved context-specific systems of circularity embedded within cultural norms, social institutions, and ecological ethics. Circularity in these settings extends beyond material reuse to include ecological restoration, collective governance, and intergenerational knowledge transmission, ensuring both environmental resilience and social equity. Practices such as sustainable forest harvesting, integrated farming, and zero-waste livelihoods illustrate functional circular systems that operate without reliance on industrial technologies. By foregrounding Indigenous Knowledge Systems, the study highlights the value of integrating traditional ecological wisdom into modern sustainability and circular economy frameworks. Such integration offers culturally grounded, inclusive, and scalable pathways for sustainable development, particularly in developing economies. Recognizing indigenous practices as living circular systems bridges the gap between policy-driven sustainability agendas and community-based regenerative traditions, reinforcing the need for holistic socio-ecological approaches aligned with long-term environmental stewardship and social well-being.

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