DST-AMRITA TECHNOLOGY ENABLING CENTRE

HALF YEARLY REPORT

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“Today, universities are ranked mainly based on funding, the number of papers they publish and their intellectual caliber, but we should also consider how much their research can serve the lowest and most vulnerable strata of society. Only by strengthening the base of the society does the entire edifice grow healthy and strong”

- Sri Mata Amritanandamayi Devi, Chancellor,
Amrita Vishwa Vidyapeetham at United Nations Academic Impact.

Amrita - Technology Enabling Centre

The Technology Enabling Centre (TEC) at Amrita Vishwa Vidyapeetham, supported by the Department of Science and Technology, Govt. of India, fosters an innovation ecosystem by connecting researchers, institutes, labs, and industry. TEC ensures market-ready technologies through collaboration and technology transfer. With a focus on bridging research and industry, TEC aligns interests to create sustainable partnerships.

Mission

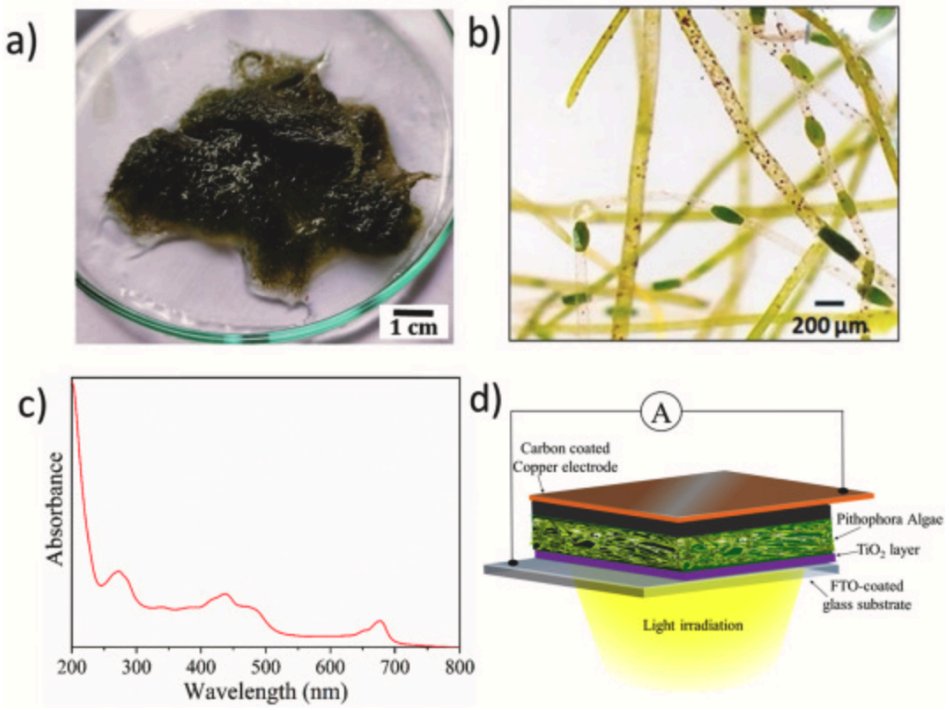
To create an ecosystem that contributes to empowering the scientific and business community and enhancing the innovation potential of both - the state and the country as a whole.

Vision

To emerge as the academic hub for innovation by providing synergy and support to other academic institutions and MSMEs.

Technologies Developed

1. Bio-Photovoltaic Device Utilizing Freshwater Macroalgae



A simple bio-photovoltaic device was fabricated with filamentous macroalgae Pithophora roettleri as the photoactive material. The filamentous algae Pithophora, belonging to the family of green algae, generally grows at the bottom or forms dense mats on the surface of aquatic habitats. A device was fabricated by sandwiching the algal biofilm between activated carbon-coated copper (Cu) and titanium oxide (TiO2) coated fluorine-doped tin oxide (FTO) coated glass slides. The optimised fabricated device exhibited a considerable amount of photo-generated current and voltage under white and UV light irradiation. The optimised device (with an area of 1 cm^2) exhibited a short circuit photocurrent of

10.19 µA and an open circuit photovoltage of 0.35 V under white light (100 mW/cm²) irradiance, and exhibited a photocurrent of 1.25 mA and a photovoltage of 0.5 V under UV light (365 nm LED with 20 mW/cm² intensity). To understand its applicability, 10 devices were connected in series, delivering 5.53 V outdoors under natural sunlight with 0.6 Sun intensity.

2. Cashew Grading Machine developed with MAKS Automation (P) Ltd.

The Cashew Cluster from Kerala, facing significant challenges in maintaining productivity and competitiveness, approached the DST Amrita Technology Enabling Centre (Amrita TEC) for innovative technological interventions. The cashew industry, a cornerstone of Kerala's economy, has been grappling with rising labor costs, declining productivity, and growing competition from global players such as Vietnam and Tanzania. Traditional manual grading methods, which are

labor-intensive and time-consuming, have made it increasingly difficult for local processors to meet international quality standards while keeping costs under control.

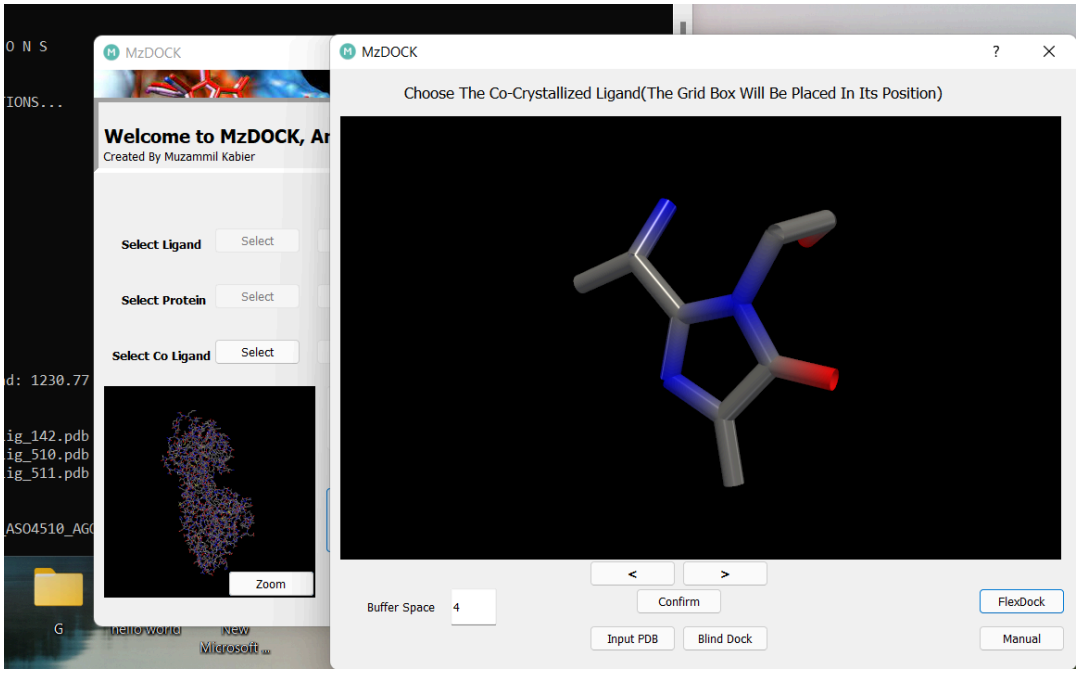
To address these pressing concerns, Amrita TEC, in collaboration with MAKS Automation, took the initiative to design and develop a novel cashew grading machine tailored to the unique requirements of the Kerala Cashew Cluster. This state-of-the-art machine leverages advanced automation technologies to streamline the cashew grading process, ensuring precise sorting based on critical parameters such as size, and quality. By significantly reducing reliance on manual labor, the machine not only minimizes operational costs but also enhances productivity and throughput.

One of the standout features of the grading machine is its ability to optimize resource utilization, reduce material wastage, and ensure consistent product quality across batches. These improvements are instrumental in helping cashew processors secure higher market prices for their products, both domestically and internationally. Additionally, the automated system alleviates the physical strain on workers by reducing their exposure to repetitive and labor-intensive tasks, creating a safer and more efficient work environment.

The development of this grading machine also represents a strategic move towards addressing labor shortages in the industry while simultaneously empowering small and medium-sized enterprises (SMEs) to adopt modern technology. This intervention has the potential to revitalize Kerala's cashew industry, enabling it to compete more

effectively in the global market, ensure better price discovery for farmers, and foster sustainable growth for years to come.

3. MzDOCK: Multiple Ligand Docking Tool - Advanced Molecular Docking Virtual Screening Tool for Drug Discovery Research



MzDOCK is a cutting-edge molecular docking virtual screening tool designed to accelerate drug discovery research with seamless integration of Python and Batch scripts, ensuring synchronized functionality across Windows and Linux Ubuntu 22.04 platforms. Compatible with PyMOL-open-source for visualizing protein-ligand interactions (PSE files) and integrated with the JSME Editor for molecule drawing, MzDOCK provides an intuitive and robust environment for researchers. Its feature-rich framework supports multiple ligand docking, side chain flexibility, and virtual screening while enabling co-crystallized ligand-based binding site configuration through a user-friendly swap window. Optimization is enhanced with forcefields such as MMFF94, MMFF94s, UFF,

GAFF, and Ghemical, offering precision and reliability. MzDOCK accommodates diverse ligand input formats (.pdb, .sdf, .mol, .mol2, SMILES) and includes options to retain water molecules, ions, and cofactors in protein-ligand complexes. Additionally, it generates a comprehensive analysis report, empowering researchers with detailed insights for informed decision-making in structure-based drug design. Molecular docking serves as a vital computational technique to study binding affinity and interactions between protein receptors and compounds, including small organic molecules, natural compounds, or peptides. It plays a crucial role in virtual screening to filter potential compounds, saving both time and costs, while also providing theoretical insights into compound activity.

Furthermore, ongoing developments include an ML-based QSAR model generator for predictive modeling, RetroScheme for generating retrosynthetic pathways to identify starting materials and optimize synthetic routes, OpenFieldAI – an AI-driven tracker system designed to automate open-field testing for neurodegenerative and psychiatric disorders, and EZPrimer, a tool for designing primers with data integration from genomic databases, ensuring efficient primer design based on specific experimental requirements. Together, these tools complement MzDOCK, expanding the technological suite available for advanced computational research in drug discovery and related fields.

Technologies Mined

Technology mining stands at the forefront of DST-Amrita Technology Enabling Centre's (TEC) mission, driving strategic exploration, identification, and extraction of impactful technologies. This initiative draws from a diverse array

of sources, including Amrita Vishwa Vidyapeetham's robust intellectual property portfolio, projects recommended by the Department of Science and Technology (DST), and innovative solutions emerging from academic institutions and entrepreneurial startups.

As a central hub for innovation, DST-Amrita TEC focuses on identifying promising technologies and helping them grow into practical solutions. The center works closely with researchers, industries, and startups to bridge the gap between research and real-world applications. By simplifying the path from discovery to implementation, DST-Amrita TEC supports industries and communities with effective and sustainable technologies, driving progress and positive change.

Table 1: Key Technologies Identified Through DST-Amrita TEC's Technology Mining Initiatives

Sl No	**Technology Title**	**Technology Classification**
1.	Elderly Care Companions	Healthcare
2.	Enhanced Agro Waste to Bioenergy Conversion Unit	Agricultural Technologies
3.	AmpouleNIP	Healthcare
4.	patX - patina removal from bimbili fruit	Environment
5.	EcoNest Intelligent IoT Home Automation Solution	Internet of Things (IoT)
6.	Herd-Infused Coir Pots	Agricultural Technologies
7.	Unlock Your English Potential	Software

8.	Affordable AI Accelerator Board	Artificial Intelligence (AI)
9.	Happi-E-Notebook	Software
10.	AI-Driven Prototype Software for Automated Ayurvedic Treatment Recommendations	Artificial Intelligence (AI)
11.	Eco-friendly Packaging Solutions	Environment
12.	Solar Steam Energy	Energy
13.	Bringing Flavors Together	Food
14.	Biodegradable Tableware Cutlery from Coir Baby Fiber	Food
15.	Sustainable and Eco-Friendly Green Material Composite Paper	Environment
16.	High carbon containing biomaterial offering honeycomb morphology	Nano Technologies
17.	EcoPet Wooden Companion	Miscellaneous Sector
18.	LactiEase Nursing Camisole	Healthcare
19.	ReTowel Smart Dispenser	Environment
20.	ComfyHome Wear Set	Miscellaneous Sector
21.	EcoCharge Wireless Hub	Energy
22.	FocusLite Smart Desk Lamp	Software
23.	ShieldRide Bike Cover	Automobile
24.	AutoSterile Cotton Machine	Healthcare
25.	ErgoFlex Pillow Cover	Miscellaneous Sector
26.	NutriPaw Dog Meal	Food
27.	SockEase Mobility Aid	Assistive Technology
28.	CocoWash Laundry Pods	Environment

29.	BioBrush Eco Toothbrush	Waste Management Technology
30.	FuelGuard Tank Cover	Automobile
31.	GreenCare Cloth Pads	Health Care
32.	DryRide Seat Shield	Automobile
33.	SafeGas Leak Detector	Internet of Things (IoT)
34.	PureMedi Filter	Healthcare
35.	MediPac Portable OT	Healthcare
36.	EcoPet Wooden Companion	Miscellaneous Sector

Table 2: Technology Distribution Across Key Classification Categories

Technology Classification	**Count of Technologies**
Agricultural Technologies	2
Artificial Intelligence (AI)	2
Assistive Technology	1
Automobile	3
Energy	2
Environment	5
Food	3
Health Care	1
Healthcare	6
Internet of Things (IoT)	2
Miscellaneous Sector	4
Nano Technologies	1
Software	3

Waste Management Technology	1
Grand Total	36

Figure 1: Classification of Technologies Across Different Sectors

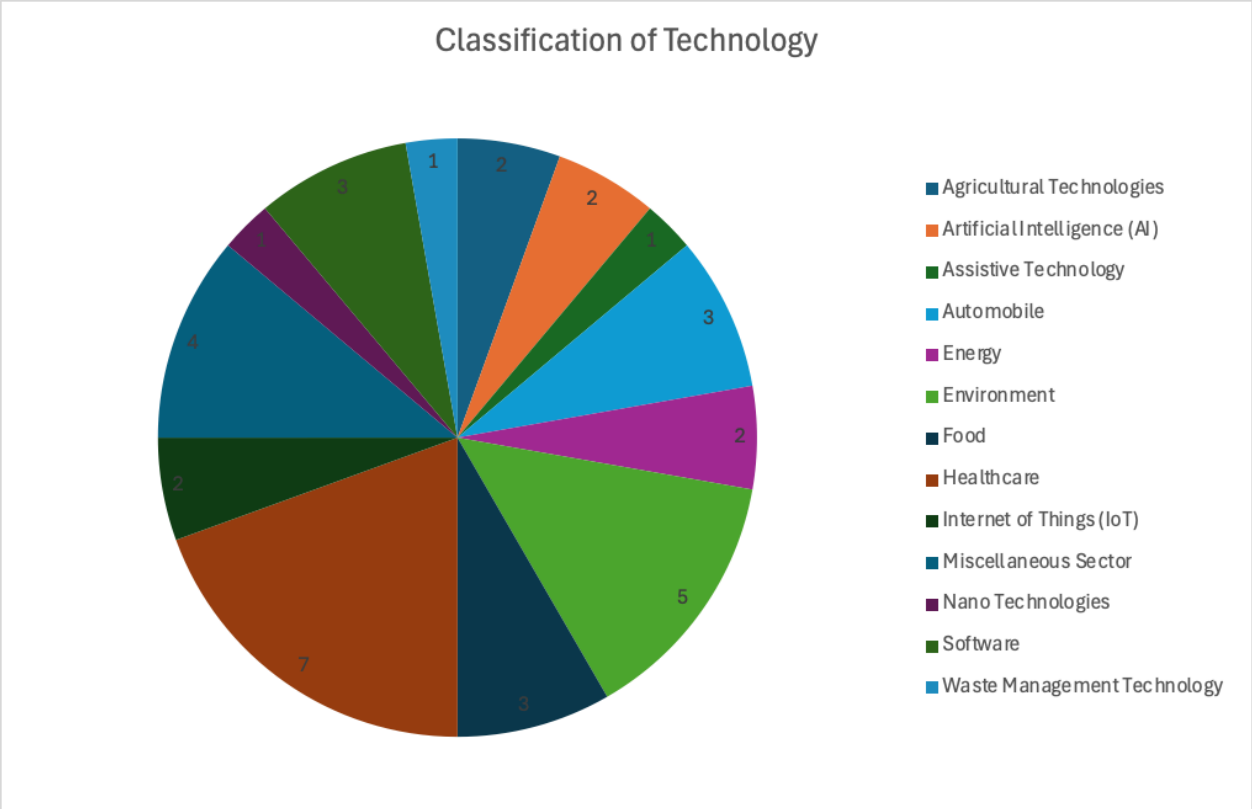


Table 3: Overview of Key Technology Projects and Their Descriptions

SI No	Project Title	Description
1.	Elderly Care Companions Personalized In-Home Support for Seniors	Personalized in-home care for seniors, offering companionship, respite care, and transportation to improve quality of life and independence while supporting families.

2.	Enhanced Agro Waste to Bioenergy Conversion Unit with Integrated Aerobic and Anaerobic Process-(IAAPU)	Combines aerobic and anaerobic processes to convert agro waste into bioenergy, creating biogas and nutrient-rich compost, while reducing processing time.
3.	AmpouleNIP	A dual-compartment ampoule opener that safely holds ampoules for one-handed operation, reducing risk in high-pressure medical environments.
4.	patX, development of eco-friendly patina removal from bimbili fruit	Eco-friendly patina remover made from bimbili fruit extract, replacing harmful chemicals, benefiting households and heritage conservation.
5.	EcoNest Intelligent IoT Home Automation Solution	IoT-enabled home automation system offering energy optimization, security, and convenience, integrating AI for a sustainable lifestyle.
6.	Herb-Infused Coir Pots as a replacement for chemical pesticides and insecticides	Herb-infused biodegradable coir pots act as natural pest repellents, supporting eco-friendly agriculture, and promoting soil health.
7.	Unlock Your English Potential, One Lesson at a Time	Personalized English learning platform with live sessions, interactive paths, and subscription pricing for diverse learners.

8.	Affordable AI Accelerator Board for Industry 5.0	Low-cost AI accelerator board making AI technology accessible for education and small industries, reducing dependence on imports.
9.	Happi-E-Notebook	Digital notebook with cloud connectivity, smart search, and AI tutoring features, offering a sustainable alternative to paper notebooks for students.
10.	AI-Driven Prototype Software for Automated Ayurvedic Treatment Recommendations	AI-based tool for Ayurvedic treatment recommendations, integrating traditional insights with modern AI for efficient decision-making.
11.	Eco-friendly Packaging Solutions Promoting Sustainable Biodegradable Plastics for a Greener Future	Biodegradable plastics made from renewable resources, reduce plastic waste, supporting agriculture, healthcare, and retail.
12.	Solar Steam Energy	Solar-powered steam energy system generates electricity without fossil fuels, offering a low-cost, renewable energy solution for rural areas.
13.	Bringing Flavors Together, Wherever You Are	A restaurant brand offering diverse, high-quality, sustainable meals for urban youth and corporate clients, focusing on eco-friendly practices.

14.	Biodegradable Tableware Cutlery from Coir Baby Fiber	Sustainable tableware from coir fiber offers an eco-friendly alternative to plastic, ideal for food and hospitality industries.
15.	Sustainable and Eco-Friendly Green Material Composite Paper	Uses water hyacinth and agricultural waste to create sustainable packing paper, providing an eco-friendly alternative for packaging.
16.	High carbon containing biomaterial offering honeycomb morphology for energy storage application	Biomaterial from coconut rachis provides a sustainable source of carbon for energy storage, advancing eco-friendly supercapacitors and batteries.
17.	EcoPet Wooden Companion	Eco-friendly, handcrafted wooden pet product designed to reduce plastic waste and promote sustainability.
18.	LactiEase Nursing Camisole	Innovative camisole with built-in nursing pads designed for hyperlactation management, offering comfort, discretion, and style for breastfeeding mothers.
19.	ReTowel Smart Dispenser	Sensor-activated reusable cloth towel dispenser reducing environmental waste and operational costs from paper towels and dryers.

20.	ComfyHome Wear Set	Padded T-shirt and shorts set offering support without bras, made from breathable fabric for home comfort.
21.	EcoCharge Wireless Hub	Eco-friendly wireless charger with Qi compliance, offering efficient, clutter-free charging in public spaces.
22.	FocusLite Smart Desk Lamp	Smart study desk light with focus timer, ambient lighting control, and app-based reminders for distraction-free productivity.
23.	ShieldRide Bike Cover	Semi-automatic bike cover offering protection from weather, dust, and theft, made from heavy-duty materials.
24.	AutoSterile Cotton Machine	Automates cotton ball production and sterilization, reducing labor and contamination risks in healthcare facilities.
25.	ErgoFlex Pillow Cover	Adjustable pillow cover with modular layers for customizable firmness and temperature control, enhancing sleep quality.
26.	NutriPaw Dog Meal	Affordable, nutritious dog food made from locally sourced ingredients, catering to dogs of all life stages.

27.	SockEase Mobility Aid	Eco-friendly device aiding individuals with limited mobility in wearing socks independently.
28.	CocoWash Laundry Pods	Single-use, eco-friendly laundry pods using coconut-derived ingredients for sustainable washing.
29.	BioBrush Eco Toothbrush	Biodegradable toothbrush with a wooden handle and BPA-free nylon bristles, reducing plastic waste.
30.	FuelGuard Tank Cover	Water-resistant cover preventing rainwater seepage into two-wheeler fuel tanks, ensuring engine health.
31.	GreenCare Cloth Pads	Reusable sanitary cloth pads offering enhanced coverage, comfort, and eco-friendliness.
32.	DryRide Seat Shield	Water-resistant bike seat cover providing moisture protection, portability, and durability for riders.
33.	SafeGas Leak Detector	Smart gas leak detector with Wi-Fi and SIM-based alerts for early leak detection and automatic shut-off.
34.	PureMedi Filter	Silicon mesh filter preventing microscopic glass particles from contaminating injectable medications.

35.	MediPac Portable OT	Portable operation theater kit designed for rapid medical response in disaster-prone and remote areas.
36.	EcoPet Wooden Companion	Eco-friendly, handcrafted wooden pet product designed to reduce plastic waste and promote sustainability.

Technologies Commercialised

1. Empowering Kerala's Cashew Cluster: Commercialisation of Cashew Grading Machine

The Cashew Cluster from Kerala approached the DST Amrita Technology Enabling Centre (TEC) to address critical challenges in cashew processing, including labor shortages, high processing costs, and reduced global competitiveness. In collaboration with MAKS Automation, Amrita TEC successfully developed an innovative cashew grading machine designed to enhance productivity, improve sorting accuracy, and significantly reduce labor dependency and associated costs. This novel technology was commercialized with support from the Ministry of MSME, aiming to benefit cashew manufacturers across Kerala by improving efficiency and sustainability in the processing sector. As a gesture of recognition and commitment to ensuring the technology reaches the industry and benefits the cashew community, a plaque was handed over to Shri G.S. Prakash IEDS, Joint Director of the MSME Development Institute, Thrissur, Kerala, by Sri Mata Amritanandamayi Devi, Chancellor of Amrita Vishwa Vidyapeetham. This initiative underscores a significant step towards empowering the cashew industry, fostering socio-economic development, and sustaining Kerala's prominence in the global cashew market.

2. Commercialisation of Customized Rotary Dryer with a Regulated Environment and Hybrid Heating for Traditional Rice Processing

The Paddy Dryer, a customized rotary dryer with hybrid heating technology designed for traditional rice processing, was developed to address the unique challenges faced by Kerala's traditional paddy varieties, such as Navara, Pokkali, and Gandhakasala. This innovative dryer ensures uniform drying, preserves nutritional content, and reduces grain breakage, enhancing both

quality and yield. The dryer integrates solar, wood, and electricity-based hybrid heating systems, offering sustainable and efficient drying solutions tailored for Kerala's high-humidity climate and delicate rice varieties.

The technology was successfully commercialized with Puthanchira Kuthari Rice mill during the Vendor Development Programme organized by the MSME Development and Facilitation Office (MSME DFO) in Thrissur, Kerala, on December 4, 2024, at Golden Jubilee Hall, MSME DFO, Thrissur. The event, aimed at promoting new market access and showcasing innovative technologies, was graced by Shri. G.S. Prakash, Deputy Director, MSME-DI, Thrissur. This collaboration highlights a significant step toward empowering traditional rice processors, improving productivity, and preserving the rich heritage of Kerala's indigenous rice varieties.

Problem Statements

1. Automation of Feeding System and Safety Mechanism in Rubber Reclamation Industry

Rubber is reclaimed from worn-out tires, serving industries such as rubber mats, tyre retread, and automotive parts manufacturers. Currently, the production process involves manually feeding two small rubber mixing mills operated by four workers. For expansion, a larger rubber mixing mill is to be replaced by the existing ones. Challenges are faced in manually feeding this new mill, especially since the mixing process often requires repeated feeding of materials in three to six cycles. The input to the Mixing mill is Cooked Rubber Crumbs of a single batch of 3,500 kg, with a temperature ranging from 200 to 240 degree Centigrade. A suitable solution for efficiently feeding and refeeding materials in the new mixing mill is required.

Solutions Required:

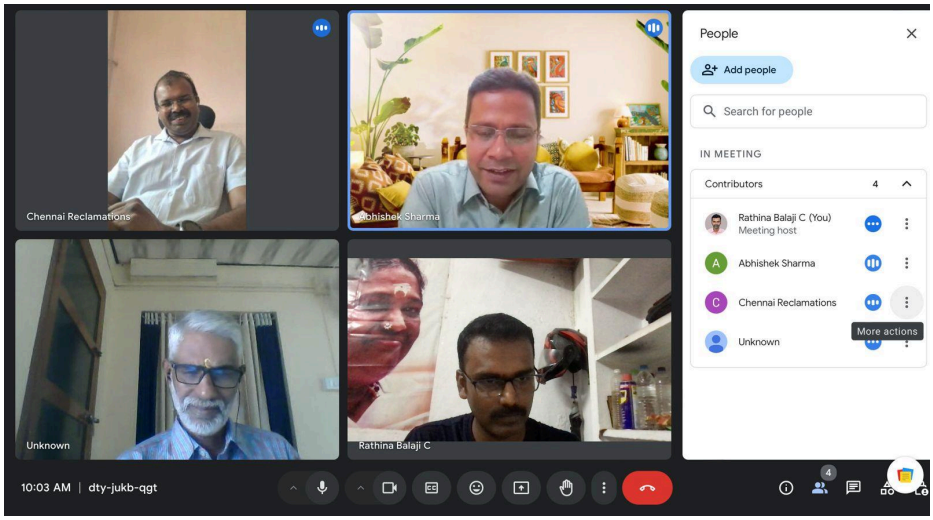
An automated material handling system designed for high-temperature applications with

Automated Feeding System: An unloading/dumping system that can automatically feed the Cooked Rubber Crumbs into the mixing mill with a controller to manage the feeding rate.

Recirculation System: A mechanism that can automatically refeed the material back into the mixing mill for the required number of cycles. This system can include a feeder, allowing the material to be cycled through the mill multiple times with or without manual intervention.

Safety Measures: Features such as emergency stop buttons and sensors to monitor the system's operation and ensure the safety of workers.

Automated Control System: An advanced material control system that manages the entire feeding and refeeding process. This system can be programmed to handle the specific requirements of the mixing cycles, engage the mixing mill rollers in different gap positions on different cycles and ensure precise control over the material handling process. By implementing this automated material handling system, Chennai Reclamations Pvt Ltd. can enhance the efficiency of the mixing process, reduce manual labour, and ensure consistent quality in the production of reclaimed rubber.



An interaction was arranged with Prof. Abhishek Sharma is a Professor in Plant Design Engineering and Waste Valorization at Manipal University Jaipur was facilitated by Amrita TEC through the resource support from DST. Several key process recommendations were highlighted to address the challenges faced by Chennai Reclamations Pvt Ltd in efficiently feeding and refeeding materials into their new larger rubber mixing mill. Suggested to focus on producing superfine quality rubber crumbs and optimizing the recovery of 80–90% carbon black was emphasized to ensure higher production efficiency. Furthermore, environmental considerations, including reducing CO_2 emissions and addressing Extended Producer Responsibility (EPR) penalties, must be prioritized through sustainable and efficient processing practices. Overall, Prof. Sharma's insights underscored the importance of an integrated and automated material handling system, coupled with precise control measures, to ensure efficiency, safety, and quality in the rubber reclamation process.

2. Inefficiency of Coir Yarn Spinning Machines and Quality Issues in Two-Ply Yarn Production

The coir industry faces a critical challenge due to outdated yarn spinning machines, which fail to produce fine, high-quality, evenly spun yarn at high production speeds. Traditionally, wall-to-wall coir floor coverings dominated international markets, but the declining yarn quality has resulted in a complete loss of market share. The current spinning technology is unable to generate thinner, high-strength yarn (target: 300 meters/kg), which is essential for producing premium floor coverings.

Additionally, PVC tufting mats, a major coir-based product, suffer from significant raw material wastage due to low-quality two-ply yarn. The yarn from existing machines is inconsistent in thickness and twist, leading to 15-20% wastage during tufting. This inefficiency forces workers to manually remove defective yarn, increasing labor costs and production time.

A key requirement is the development of a next-generation coir spinning machine equipped with advanced automation and precision control to ensure uniform yarn quality. The new machine should:

• Be capable of spinning thinner, high-strength yarn to restore the market for coir floor coverings.

• Produce consistent, high-quality two-ply yarn to minimize waste in PVC tufting mats.

• Eliminate the need for a lead thread, making coir yarn more cost-effective and suitable for geo-textile applications.

Technological upgrade is required to revive lost markets, reduce material wastage, and enhance production efficiency, ultimately leading to higher profitability and global competitiveness.

3. Environmental Concerns from Coir Tufting Waste Disposal

The massive waste generation from coir tufting processes is a serious environmental issue. Across Tamil Nadu and Kerala, there are around 150 PVC tufting machines, which together generate approximately 4-5 tons of non-biodegradable coir waste every day. This trimming waste is currently discarded in landfills, causing environmental pollution and wasting valuable raw materials.

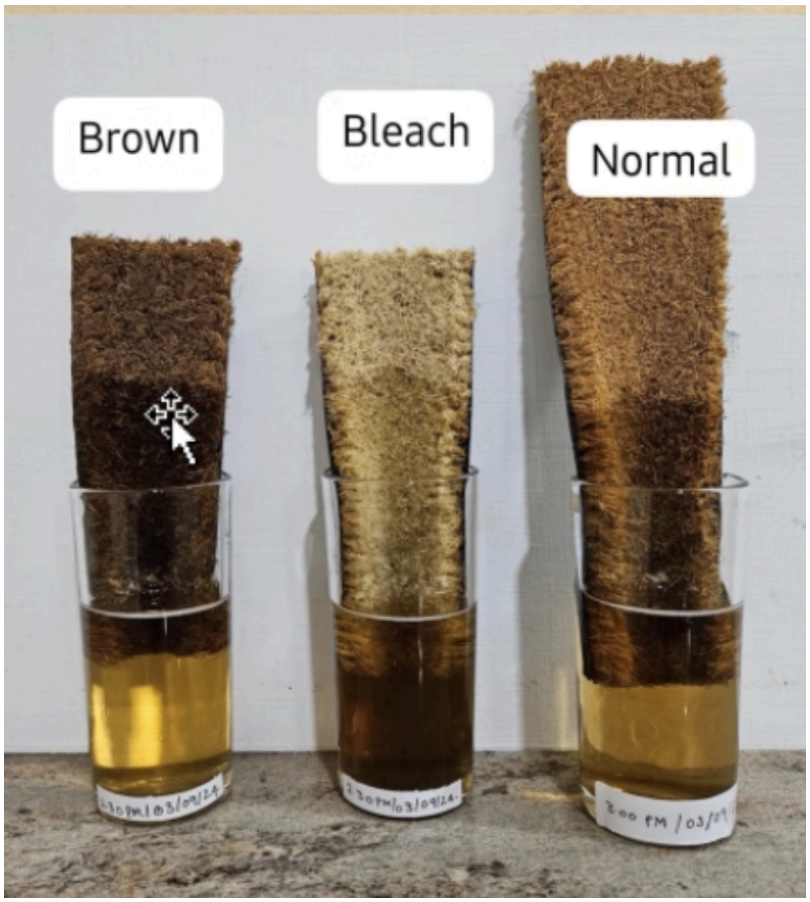
At present, no efficient recycling mechanism exists for processing this waste into useful by-products. If left unaddressed, this problem will continue to escalate, putting the industry under scrutiny for its unsustainable practices. Instead of dumping this waste, there is an urgent need for R&D-driven solutions to repurpose it into eco-friendly alternatives such as:

- Wooden pallet substitutes for packaging applications.
- Pavement tiles and partition boards for construction.
- Compressed coir composite boards for furniture and paneling.

Implementing circular economy strategies for coir tufting waste will reduce landfill pollution, create new revenue streams, and strengthen the sustainability

of the coir industry. A structured waste-to-product initiative can also position Indian coir manufacturers as leaders in sustainable fiber-based industries.

4. Quality Issues in Coir Mats Due to Tannin Bleeding and Staining



One of the biggest threats to the global acceptance of coir mats is the issue of staining due to tannin bleeding. International customers, particularly in the USA and Europe, have reported that coir mats leave stains on floors when exposed to moisture.The root cause of this issue lies in the tannin content of coir fibers. Traditionally, coir yarn was spun from retted husks, a process that removed tannins naturally. However, modern production methods have neglected this crucial step, leading to excessive color migration. Internal tests confirm that all

coir fiber types (brown, bleached, and untreated) bleed significantly when soaked in water, making them unsuitable for premium international markets.

To maintain export quality and customer trust, the industry must develop scientifically validated solutions such as:

- Eco-friendly retting processes to naturally remove tannins.
- Applying anti-bleed coatings or sealants to lock in color.
- Using water-resistant barrier treatments to prevent leaching.
- Experimenting with mild alkaline treatments to neutralize tannins before manufacturing.

Without immediate intervention, coir mats risk being blacklisted by international buyers, further weakening India's coir export industry. A rapid R&D-based solution is essential to improve product durability, prevent staining, and restore global confidence in coir-based products.

Industry, Academia & Government Bodies Tie-Ups for Technology Enablement through TEC

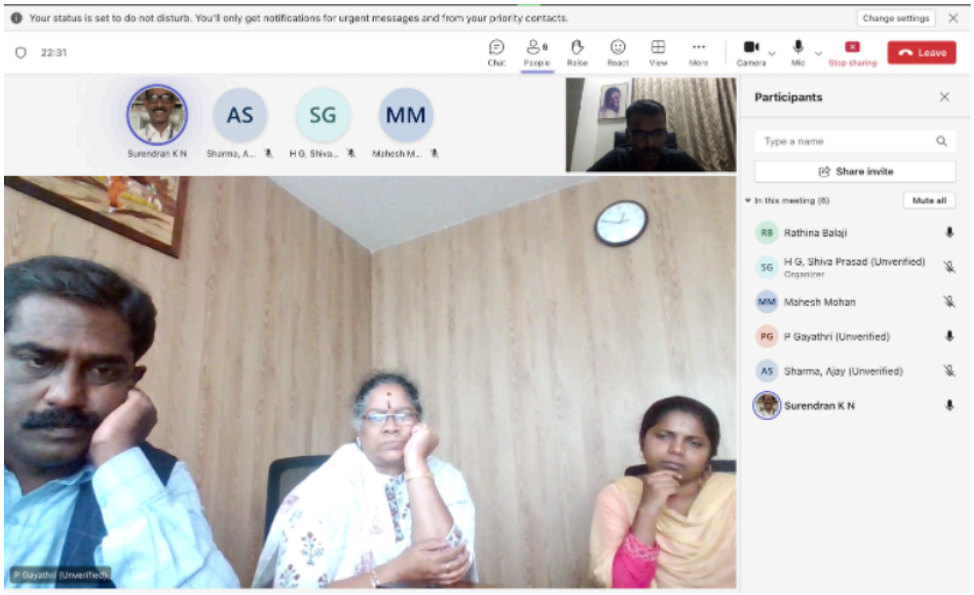
1. Engagement with SIDBI to Address Challenges in Kerala's Cashew Processing Industry

The Amrita Technology Enabling Centre (TEC) team recently held an insightful interaction with Small Industries Development Bank of India (SIDBI) to address the persistent challenges faced by cashew processors in Kerala. The meeting

focused on exploring collaborative pathways to make Amrita TEC's innovative Cashew Grading Machinemore accessible to cashew processors through soft loans supported by SIDBI.

The discussion brought together key representatives from SIDBI, including H.G. Shiva Prasad, P. Gayathri, and Ajay Sharma, alongside members of the evaluation team. The dialogue centered on understanding the ground-level issues experienced by cashew processors, such as high labor costs, inefficiencies in manual sorting, and the need for automation to improve productivity and quality consistency.

Amrita TEC presented its Cashew Grading Machine as a technologically advanced and economically viable solution to these challenges. The machine is designed to streamline the sorting process, reduce dependency on manual labor, enhance processing efficiency, and ensure superior grading precision. It promises to improve yield quality while making the entire cashew processing workflow cost-effective and scalable.



During the discussions, the SIDBI team acknowledged the significance of this intervention and expressed interest in exploring financial models, including soft loans and financial assistance, to ensure widespread adoption of the technology among cashew processors and MSMEs in Kerala.

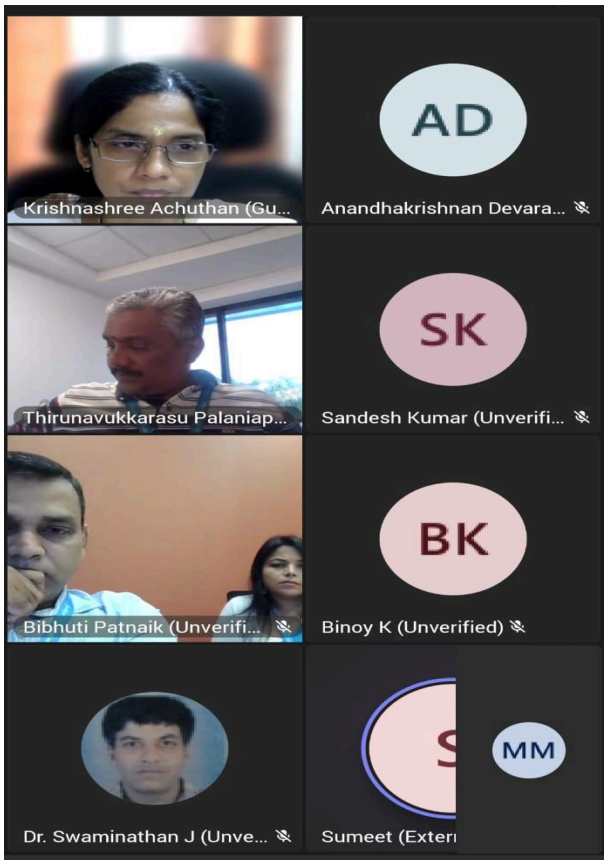
This collaborative initiative aims not only to revive the cashew industry in Kerala but also to empower local processors with modern tools, generate employment opportunities, and improve the region's competitiveness in the global cashew market.

The interaction concluded on a positive note, with both parties agreeing to take forward the proposed financial support mechanisms and work towards ensuring the Cashew Grading Machine reaches cashew processors across Kerala Efficiently and effectively.

2. Interaction with Quartet Industrial Solutions

A team from DST Amrita TEC visited Quartet Industrial Solutions in Kanjikode, where an insightful discussion took place with Mr. Vinodh M C, Director of Quartet Industrial Solutions. The company specializes in galvanizing steel, a critical process for enhancing durability and corrosion resistance in infrastructure, construction, and industrial applications. The company is seeking technologies to expand into specialty protective coatings designed for harsh environments, including extreme temperatures, high humidity, and corrosive marine conditions. These advanced coatings are targeted at sectors such as marine infrastructure, offshore platforms, and chemical plants, ensuring steel structures remain resilient under challenging conditions. Additionally, the company is keen on adopting environmentally friendly galvanizing processes to minimize hazardous emissions, reduce chemical waste, and implement energy-efficient practices, aligning with global sustainability standards. The visit could open doors for potential collaboration in the areas of research and development of advanced coatings and technology transfer in surface preparation and coatings.

3. Interaction with Wipro Ltd for Collaboration & Partnership



Dr. Krishnashree Achuthan, Director of Amrita Technology Enabling Center (TEC), facilitated a strategic interaction with senior leaders from Wipro Ltd., including representatives from the Skilling Team and Cybersecurity Division, to discuss the establishment of a Wipro-Amrita Center of Excellence (CoE) in Cyber Security and the implementation of various key initiatives in a time-bound manner. The discussions emphasized the development of industry-relevant training programs to enhance the skills of employees in the emerging area of cybersecurity. The collaboration aims to drive joint research and development activities, foster nationwide talent development programs in cybersecurity, and organize industry-academic exchange events such as technical talks, conferences, and workshops. The partnership will also focus on internship programs specializing in cybersecurity, offering them practical exposure. Furthermore, socially responsible outreach programs will be implemented to create cyber-resilient communities through structured training and awareness campaigns. Both parties agreed to prioritize these initiatives and work

collaboratively to ensure their timely execution, fostering innovation, talent development, and impactful contributions to the cybersecurity ecosystem.

4. Interaction with MSME-DI, Thrissur

The collaboration between Amrita Technology Enabling Center (TEC) and MSME Development Institute (MSME DI), Thrissur, has played a pivotal role in delivering impactful technological interventions to MSME clusters across sectors such as plywood, rice mills, agricultural consortiums, and the cashew industry. These collaborations have been instrumental in addressing key industry challenges and improving productivity through innovative solutions.

Mr. Mahesh Mohan from Amrita TEC held an insightful discussion with Shri G.S. Prakash IEDS, Joint Director of MSME Development Institute, Thrissur, focusing on the commercialization of the Cashew Grading Machine and the Hybrid Paddy Dryer. The discussions aimed to ensure that these advanced technologies reach industry clusters efficiently, enabling them to enhance operational efficiency, reduce manual dependency, and drive economic growth through sustainable and scalable innovations.

5. Amrita TEC's Collaboration with Traditional Rice Processing Clusters for Hybrid Paddy Dryer Development

The Amrita Technology Enabling Center (TEC), in collaboration with a dedicated faculty team comprising Dr. Pramod Sreedharan, Associate Professor, Mechanical Engineering, School of Engineering, Amritapuri, and Mr. Suresh Appukuttan, Assistant Professor, Department of Management, School of Business, Amritapuri, conducted an in-depth study to understand the challenges faced by traditional rice processing clusters. Through extensive field visits, stakeholder interactions, and detailed analysis, the team identified the critical need for a Hybrid Paddy Dryerto address key concerns related to uniform drying, energy efficiency, and preservation of rice quality.

As a result of these collaborative efforts, Mr. Unnikrishnan A from Puthanchira Kuthari Rice Mill recognized the significance of this intervention and came forward with a contribution of ₹50,000 towards the development and commercialization of the Hybrid Paddy Dryer. This contribution underscores the shared commitment between industry stakeholders and Amrita TEC to

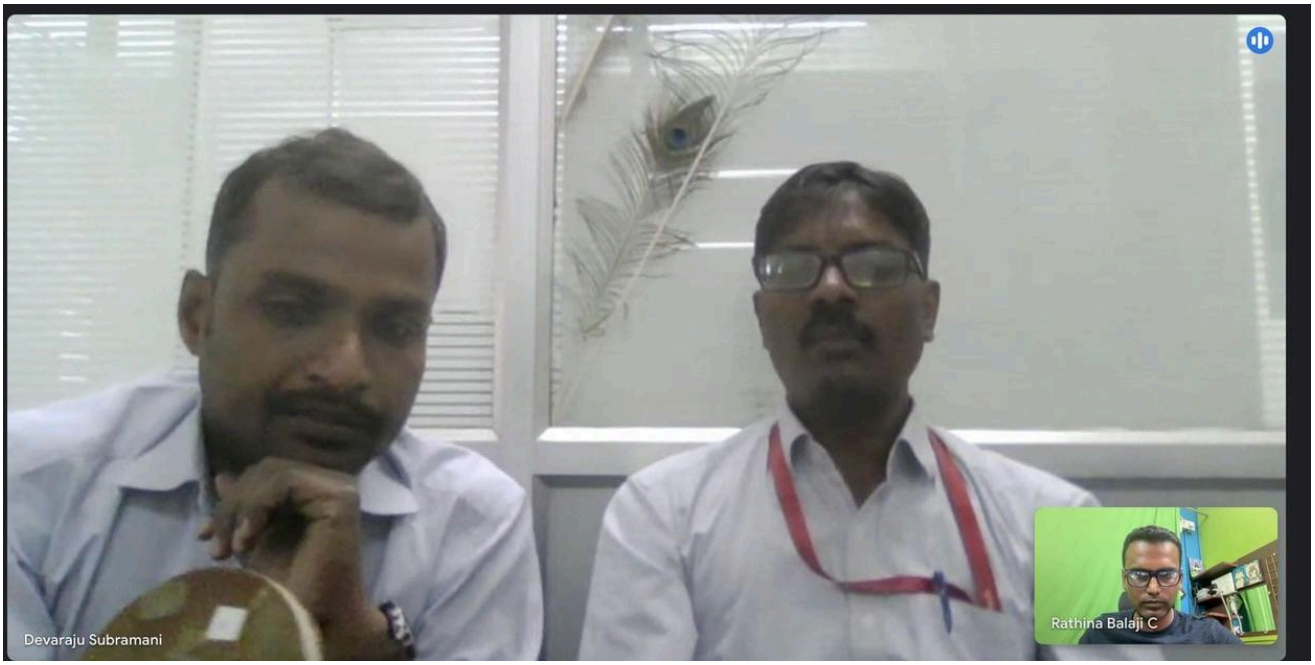
drive innovation, improve productivity, and ensure sustainable practices in Kerala's traditional rice processing sector. The Hybrid Paddy Dryer project represents a holistic approach to addressing sector-specific challenges, setting a precedent for collaborative problem-solving and industry-academia partnerships.


6. Collaboration with Bharatiya Kisan Sangh and Jai Kisan Nidhi to enhance Agricultural practises


Amrita Technology Enabling Centre (TEC) is set to provide interventions in agricultural practices by initiating discussions with the Bharatiya Kisan Sangh (BKS) in Kerala and Jai Kisan Nidhi, Kerala. The focus will be on technology integration in farming, including IoT-based monitoring systems and sustainable farming practices, to enhance productivity and resource management.

Additionally, Amrita TEC plans to conduct workshops and training sessions for farmers on modern agricultural techniques, post-harvest management, and value addition, empowering them with essential skills to improve their livelihoods. Collaborative research projects will also be pursued, concentrating on crop improvement, pest management, and soil health, to address region-specific agricultural challenges and promote sustainability.

7. Enhancing Technology Readiness of Coir Foundry Sand Composite through Industry-Academia Collaboration



The Coir Foundry Sand Composite initiative addresses waste management challenges by repurposing foundry sand and granite dust into a sustainable coir-based roofing material. Amrita Technology Enabling Centre (TEC) is supporting researchers from PSG College through consulting and securing industrial connections to enhance the Technology Readiness Level (TRL) of this innovation. A 12mm thick composite sheet (6mm coir + 6mm foundry sand

or granite dust) was prototyped using an 8ft x 4ft hot press, offering thermal and acoustic insulation as a potential replacement for metal sheets, asbestos, and polycarbonate roofing. Key challenges include thickness optimization (current 12mm vs. industry standard 1-6mm), weight reduction, production uniformity, and cost competitiveness. Amrita TEC is facilitating further R&D, cost assessment, and industry validation to refine the material and explore commercialization opportunities. This initiative underscores Amrita TEC's role in advancing technology-driven sustainability solutions by bridging academic research with industry needs.

8. Interactions with Fine Fab India

The DST-Amrita Technology Enabling Centre (TEC) engaged in a strategic discussion with Fine Fab India, a leading fabrication and engineering solutions provider, to explore partnership opportunities for the fabrication and prototyping of pollution control equipment. The interaction focused on developing innovative and cost-effective solutions for air and water pollution control systems, aligning with national sustainability goals and industrial compliance requirements. Amrita TEC highlighted its expertise in technology scouting, R&D collaboration, and commercialization, emphasizing the potential to integrate advanced materials, smart monitoring systems, and automation

technologies into pollution control solutions. Fine Fab India shared insights into its capabilities in precision fabrication, industrial prototyping, and customized engineering solutions, reinforcing the feasibility of developing high-efficiency pollution control equipment that meets industry standards and regulatory guidelines. The partnership aims to accelerate technology deployment for industries in need of sustainable environmental solutions, bridging academic research and industrial applications. Through this collaboration, Amrita TEC and Fine Fab India seek to create scalable, market-ready pollution control systems, driving impactful change in environmental management and industrial sustainability.

9. Interactions with Honorable Minister of State for Jal Shakti, Government of India

The interaction between the DST-Amrita Technology Enabling Centre (TEC) and Honorable Minister of State for Jal Shakti, Government of India, Dr. Raj

Bhushan Choudhary, focused on DST-Amrita TEC's contributions to technology transfer, industry-academia collaborations, and sustainability-driven innovations. The center has been actively supporting MSMEs, researchers, and industries in areas such as water management, sustainable materials, IoT-based industrial solutions, and technology commercialization by facilitating industry connections, intellectual property transfer, and product development. Given the Minister's focus on Jal Shakti (Water Resources), the discussion covered technology-driven interventions for water conservation, wastewater treatment, and climate-resilient solutions that align with national priorities for sustainability and industrial growth.

10. Interactions with stakeholder during Invest Kerala Global Summit

The DST-Amrita Technology Enabling Center (TEC), funded by the Department of Science & Technology (DST), Government of India, actively participated in the Invest Kerala Global Summit. The TEC connected with National Coir Research & Management Institute (NCRMI), Thiruvananthapuram, focusing on the commercialization of coir-based technologies. Amrita TEC engaged with

other key stakeholders, including industry leaders, researchers, and policymakers, to discuss technology-driven advancements in coir processing, value-added product development, and global market expansion. As part of its broader industry outreach, Amrita TEC collaborated with the District Industries Centre (DIC), Kollam, to explore potential partnerships for technology integration and industrial scaling. Discussions centered on innovative coir product commercialization, automation in coir processing, and sustainable business models to enhance the competitiveness of MSMEs in the sector. Additionally, Amrita TEC engaged with Cosy Natuur Group, a key player in the coir products industry, to facilitate the commercialization of coir-based innovations. The discussions focused on market-driven product development, quality enhancement, and global trade opportunities for coir-based sustainable solutions. Through these strategic engagements, Amrita TEC continues to strengthen its role as a technology enabler, fostering industry-academia collaborations, and driving innovation-led growth in the coir sector.

11. Interaction with National Convenor, Shiksha Sanskriti Udhyaan Nyas & Member, NMCE, Ministry of Education Govt of India

The DST-Amrita Technology Enabling Center (TEC) had the privilege of engaging in a meaningful interaction with the National Convenor, Shiksha Sanskriti Udhyaan Nyas, and Member, National Mission for Clean Energy (NMCE), Ministry of Education, Government of India. The discussion focused on fostering technology-driven educational transformation, innovation in skill development, and sustainable technology adoption in academic institutions.

Insights from Industry: Innovations and Sustainability in the Coir Industry

About Coir

COIR, known as "The Golden Fibre," is a versatile natural fiber extracted from the coconut husk. Coir is one of the oldest industries in India. Historically, its extraction method has been documented by explorers like Marco Polo. Originating in India, coir weaving began in Alleppey in 1859 and spread across the nation, becoming one of the hardest natural fibers, preferred for soil erosion control and stabilization. Coir, termed "kalpa vriksha" in Sanskrit, symbolizes a tree providing life's necessities. It's eco-friendly, recycled from coconut husks, and offers numerous applications, including rope, floor coverings, Geo-textiles, and wood furniture substitutes, contributing to waste reduction and wealth creation. India, the largest coconut producer globally, cultivates coconut husks in 18 states, meeting nationwide demand. Kerala leads in coconut production and coir products, contributing significantly to India's economy alongside other major coconut-producing states. India, with Sri Lanka, dominates global coir fibre production, producing around 280,000 metric tonnes annually. Coir products, traditionally limited to floor coverings, now include Geo-textiles, organic manure, and garden articles, reflecting the industry's adaptability and commitment to sustainability. Overall, the coir industry is pivotal in India's rural economy, providing employment and promoting eco-friendly practices.

Purpose of the White Paper

The insights in the white paper aims to:

- To inform and educate by providing a comprehensive overview of the coir industry, its products, applications, and potential.
- To identify the current research and stimulate research and development by focusing the needs of the industry, the scope of coir, and its importance for sustainability and innovation. Encouraging further research and innovation within the coir industry to enhance product quality, develop new applications, and improve manufacturing processes.

- To focus policymakers' attention on the challenges faced by the coir industry throughout its value chain, as well as the market scope and potential of coir, so they can incentivize and implement policy regulations to achieve significant growth in the coir sector.

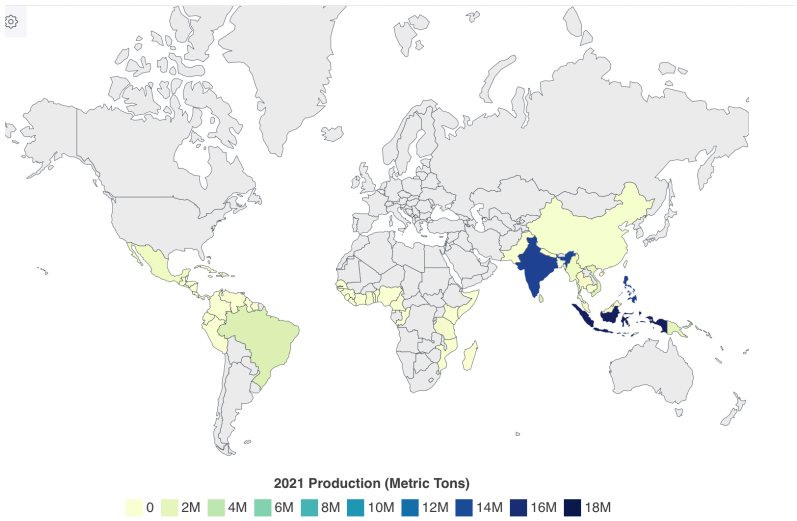
Coir Production

Coir , is a natural fibre extracted from the outer husk of coconut. Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut. The ideal conditions for coconut cultivation are

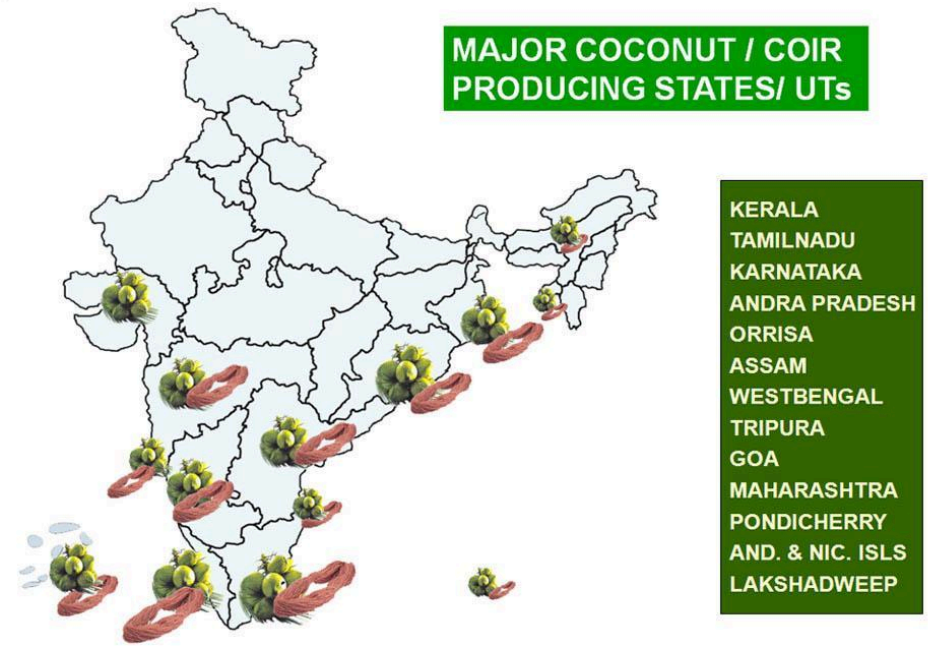
- Latitude: Between 20°N and 23°N (or 20°S and 23°S) for optimal commercial yield.
- Altitude: Up to 600 meters above sea level (MSL), although some success up to 900 MSL has been reported.
- Temperature: Mean annual temperature: 27°C and Range: 20°C to 32
- Rainfall Minimum: 1000 mm annually, ideally well-distributed throughout the year.
- Rainfall Maximum: Up to 3000 mm is suitable, but good drainage is crucial.
- Humidity: 80-85% relative humidity
- Wind: Moderate winds are beneficial for pollination and nutrient uptake.
- Sunshine: Abundant sunlight is essential. Coconut palms don't thrive in shade or cloudy conditions.
- Soil: Adaptable to various soil types including laterite, coastal sandy, alluvial, and reclaimed marshlands.
- Salinity: Tolerates slightly saline soils found in coastal areas.
- Soil pH: Wide tolerance range (from 5.0 to 8.0).

India boasts several favourable factors that grant it a strategic advantage in coconut cultivation. A large portion of the country falls within the ideal latitude and altitude range for coconut growth, enabling large-scale production. Furthermore, India's diverse landscape offers a variety of soil types suitable for coconut palms, from laterite to coastal sandy soils. This adaptability allows for efficient land utilization compared to countries with limited soil options. Additionally, India's climate, with its moderate temperatures, well-distributed rainfall patterns, and ample sunshine

hours, provides a naturally nurturing environment for coconut trees. Even the presence of slightly saline soils in coastal areas and a wide soil pH tolerance range add to India's advantage, allowing for coconut cultivation in diverse regions. These factors combined create a cost-effective and large-scale coconut cultivation potential, making India a major player in the global coir market.



Global Coconut Production Heat Map



Physical & Chemical Properties of Coir

Coir is the fibrous husk of the coconut shell. It is tough and naturally resistant to seawater, the coir protects the fruit enough to survive months floating on ocean currents to be washed up on a sandy shore where it may sprout and grow into a tree, if it has enough fresh water, because all the other nutrients it needs have been carried along with the seed. The physical and chemical properties are as show below

Chemical Properties of Coir	Physical Properties of Coir
Lignin 45.84%	Length in inches 6-8
Cellulose 43.44%	Density (g/cc) 1.40
Hemi-Cellulose 00.25	Tenacity (g/Tex) 10.0
Pectin's and related Compound 3.0%	Breaking elongation% 30%
Water soluble 5.25%	Diameter in mm 0.1 – 1.5
Ash 2.22%	Rigidity of Modulus 1.8924 dyne/cm2
	Swelling in Water (diameter) 5%
	Moisture at 65% RH 10.50%

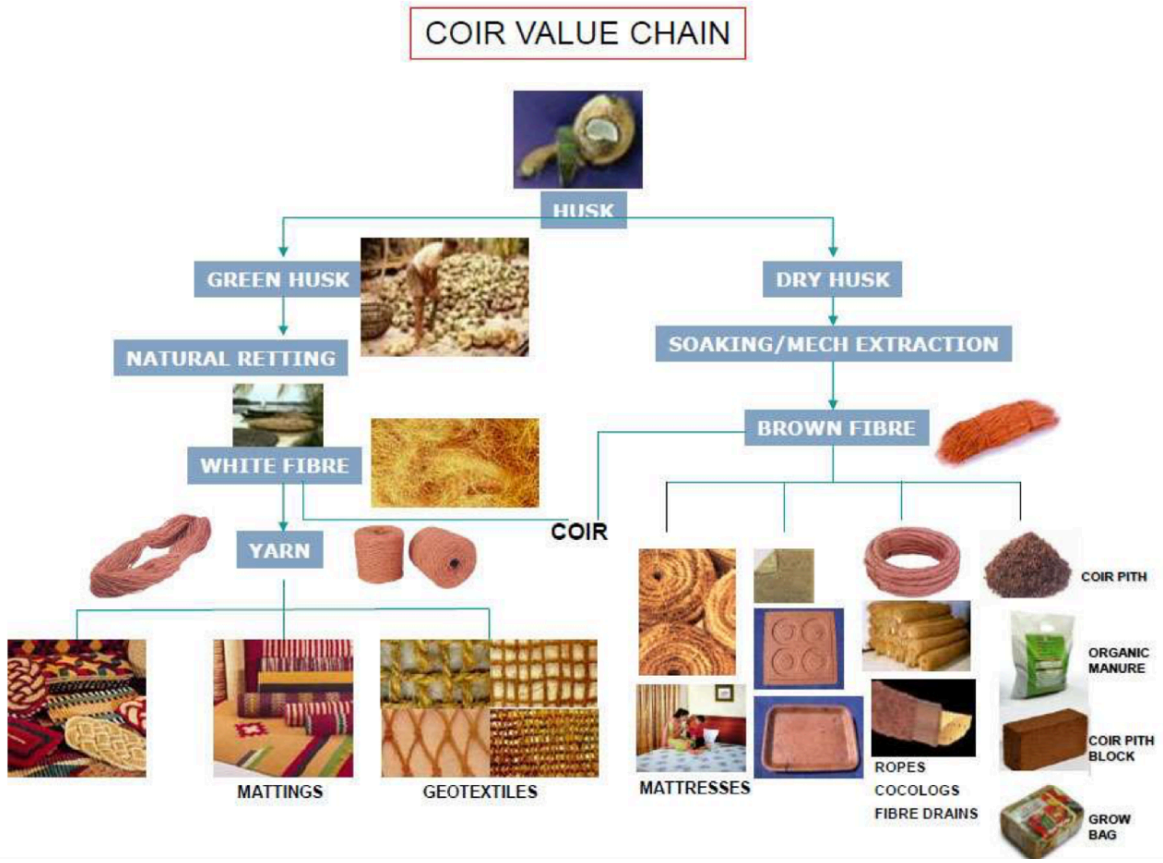
The high content of lignin (45.84%) contributes to coir's strength and resistance to wear and tear. Lignin also plays a role in coir's resistance to rot and mold growth. This extends the lifespan of coir products and makes them suitable for use in humid environments. The high cellulose content (43.44%) makes it biodegradable. The cellulose also contributes to coir's ability to absorb water. Beyond being eco-friendly, coir offers a remarkable range of advantages listed as follows.

- Moth-proof; resistant to fungi and rot.
- Provides excellent insulation against temperature and sound.
- Not easily combustible.
- Flame-retardant.
- Unaffected by moisture and dampness.
- Tough and durable.
- Resilient; springs back to shape even after constant use.
- Totally static free.

- Easy to clean.

Coir Value Chain

The various advantages of coir makes it a highly functional and versatile material creating a huge demand for coir and the coir value chain takes coconut husks, a byproduct of harvesting, and transforms them into a diverse range of useful products. The process starts with either green or dry husks, which undergo natural retting (soaking) or a combination of soaking and mechanical extraction to separate the valuable coir fibres. These fibres are then categorized as brown, ideal for brushes and matting, or white, used for higher-value applications due to their strength. The diagram showcases some of the final coir products, including yarn for ropes and mats, geotextiles for erosion control, mattresses for their natural support, and even coir pith, a valuable organic fertilizer. This transformation from a byproduct to useful and eco-friendly products highlights the efficiency and sustainability of the coir value chain.



Leveraging its ideal location for coconut cultivation and the inherent versatility of coir, India has emerged as a leading global supplier of coir fiber. Coir fiber exports are steadily increasing in volume, yet the export value in 2022-23 (Rs. 52,851.99 crore) is lower compared to 2018-19 (Rs. 60,164.11 crore). This is despite a significant rise in export volume during the later year (4,46,340 MT) compared to the former (2,99,279 MT). Potential reasons for this discrepancy could be increased global coir supply or lower demand for coir products. Interestingly, the United States is the top export destination by value (29.7%), while the Republic of China leads in terms of import quantity (44.69%), though their value contribution remains lower (20.42%). However, recent export data reveals a gap between increasing volume and decreasing value. To address this concern and fully harness coir's potential, building an innovation ecosystem, developing value-added coir products, and fostering a supportive infrastructure are crucial priorities.

Export of Coir and Coir Products for the last 5 Years (2018-19 to 2022-23)

Quantity in MTs — Value Rs. in lakh

	2018-19		2019-20		2020-21		2021-22		2022-23	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
COIR FIBRE	299279	60164.11	308457	49842.6	354123	62890.57	399428	63655.79	446340	52851.99
COIR YARN	3408	2642.23	11290	2681.57	3849	2919.30	4285	3330.73	4150	2908.75
HANDLOOM MATS	19367	21911.04	16910	19630.1	20527	24662.10	21079	26172.99	26287	31071.63
TUFTED MATS	54131	52225.03	58300	56344.1	81799	80690.82	92810	100114.57	96389	104788.31
POWERLOOM MATS	8	15.89	26	49.65	65	106.51	408	753.80	419	887.82
HANDLOOM MATTING	1071	1436.08	1177	1366.41	1418	1712.00	1110	1423.21	1224	1831.62
POWERLOOM MATTING	7	17.22	5	8.53	11	19.24	4	9.62	0	0.00
COIR GEO- TEXTILES	7674	5972.56	8068	6389.45	8583	7059.05	6978	6165.74	10096	9067.32
COIR RUGS & CARPET	195	243.96	367	483.82	327	427.90	580	861.79	711	1011.32
COIR ROPE	486	439.79	512	466.03	505	491.76	716	649.84	754	663.42
CURLED COIR	10768	3137.02	3028	2301.22	9381	2422.22	9943	2622.89	14753	3784.89
RUBBERISED COIR	807	1029.58	578	786.82	982	1321.41	644	1096.88	410	739.20
COIR PITH	566661	123208.48	579980	134963	680898	191974.07	696175	225917.69	661629	186859.95
COIR OTHER SORTS	183	361.58	298	476.93	744	1200.96	696	1229.56	1622	2751.75
TOTAL	**964046.4**	**272804.57**	**988996**	**275790**	**1163213**	**377897.91**	**1234855**	**434005.10**	**1264784**	**399217.97**

Source: Coir Board

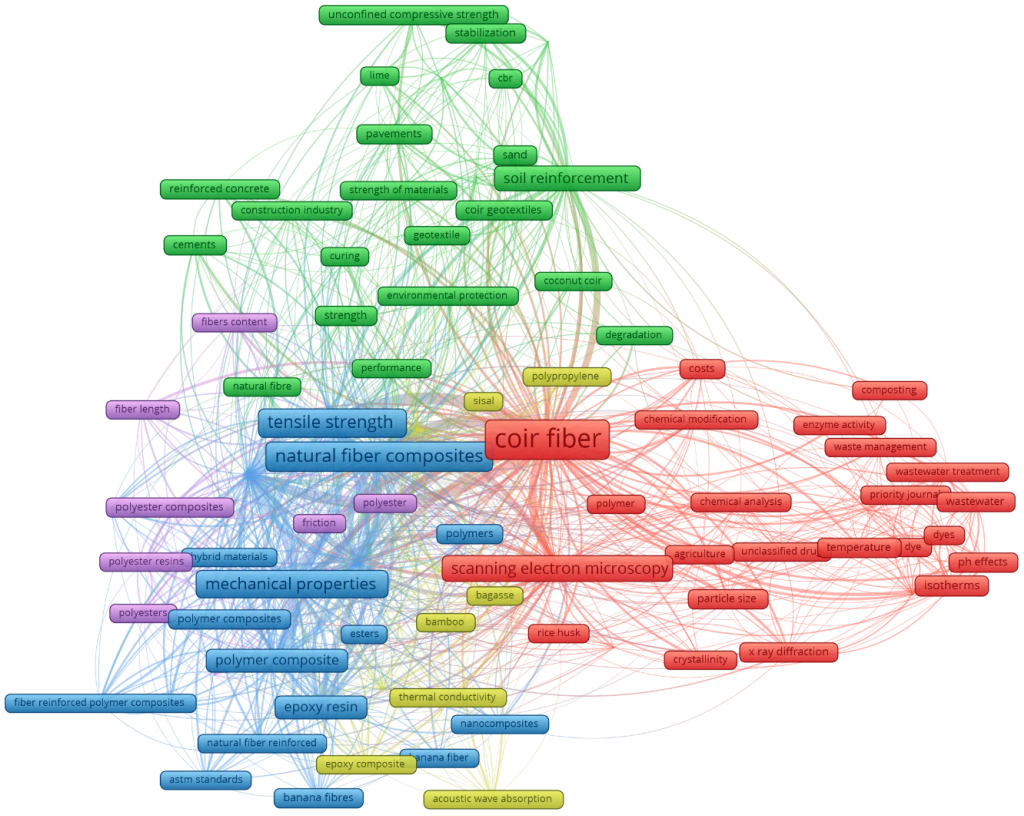
Country wise Export of Coir & Coir Products - 2022-23					
Quantity in MT					Value in Rs.Lakhs
Sl.No.	Country	Quantity	Value	QTY%	VAL%
1	USA	161307	117646.75	12.75	29.47
2	REPUBLIC OF CHINA	565250	81520.21	44.69	20.42
3	NETHERLANDS	74324	24352.37	5.88	6.1
4	SOUTH KOREA	91613	19528.04	7.24	4.89
5	UK	39459	18426.91	3.12	4.62
6	SPAIN	52497	16363.70	4.15	4.1
7	AUSTRALIA	28210	14105.84	2.23	3.53
8	GERMANY	20794	11602.16	1.64	2.91
9	ITALY	20057	9925.68	1.59	2.49
10	FRANCE	12590	8600.80	1	2.15

Market acceptance, competition from synthetic alternatives, pricing pressures.

Source: Coir Board

Research Trends in Coir

Research and development (R&D) play a critical role in the growth, progress, and sustainability of the coir industry. Innovative solutions are essential for enhancing production processes, creating new applications, and promoting the eco-friendly potential of coir. In this section, we will explore the broad areas of ongoing research and highlight some leading articles in the field of coir. R&D in this sector requires significant funding, along with active involvement from stakeholders. A list of top funding agencies supporting coir-related research is also provided.



Area of research focused by Institutions in the area of coir

The table below presents recent research conducted by researchers on coir, showcasing their findings and comprehensive recommendations based on their exhaustive research.

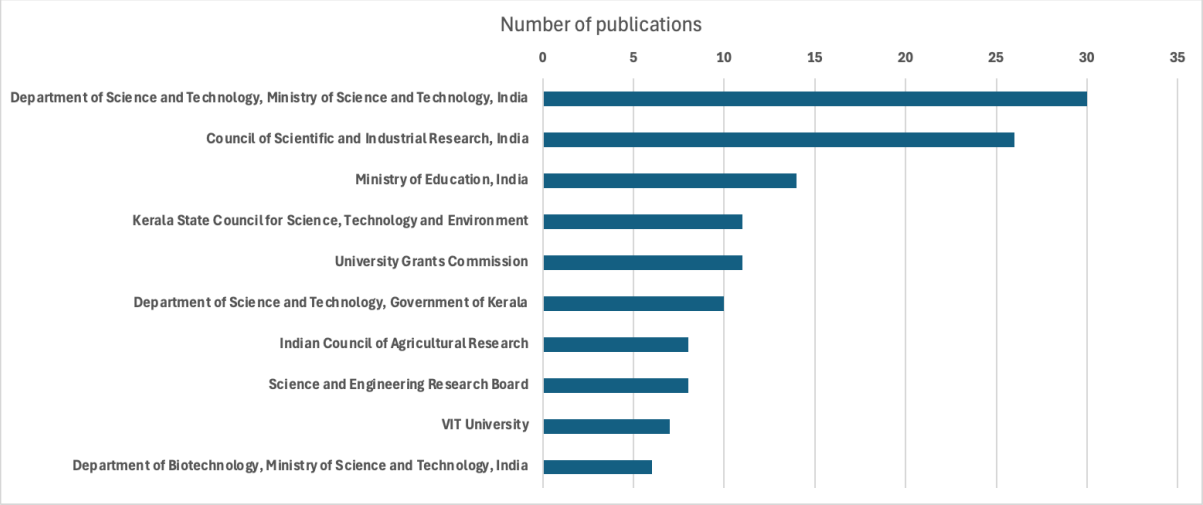
Authors	Title	Finding	Source Title
Raj B.; Sathyan D.; Madhavan M.K.; Raj A.	Mechanical and durability properties of hybrid fiber reinforced foam concrete	Coir fiber reinforced foam concrete shows superior functional and durability characteristics compared to PVA fiber reinforced foam concrete	Construction and Building Materials
Chokshi S.; Parmar V.; Gohil P.; Chaudhary V.	Chemical Composition and Mechanical Properties of Natural Fibers	Potential for diverse applications in industries like textiles, automotive, and construction	Journal of Natural Fibers
Singh Y.; Singh J.; Sharma S.; Lam	Fabrication and characterization of	Coir fiber/carbon fiber/epoxy resin hybrid	Journal of Materials

T.-D.; Nguyen D.-N.	coir/carbon-fiber reinforced epoxy based hybrid composite for helmet shells and sports-good applications: influence of fiber surface modifications on the mechanical, thermal and morphological properties	composites exhibit better mechanical properties (tensile, compressive, flexural, and impact strength) and improved thermal stability compared to single fiber-reinforced composites.	Research and Technology
Biruntha M.; Karmegam N.; Archana J.; Karunai Selvi B.; John Paul J.A.; Balamuralikrishnan B.; Chang S.W.; Ravindran B.	Vermiconversion of biowastes with low-to-high C/N ratio into value added vermicompost	Investigated vermicomposting of seaweed, sugarcane trash, coir pith, and vegetable waste mixed with cow dung using **Eudrilus eugeniae** over 50 days.	Bioresource Technology
Sreenivas H.T.; Krishnamurthy N.; Arpitha G.R.	A comprehensive review on light weight kenaf fiber for automobiles	The research highlights that natural fibers like coir, when used in hybrid composites, can contribute to the development of sustainable materials with enhanced mechanical properties for various industrial applications.	International Journal of Lightweight Materials and Manufacture
Nayak S.Y.; Sultan M.T.H.; Shenoy S.B.; Kini C.R.; Samant R.; Shah A.U.M.; Amuthakkannan P.	Potential of Natural Fibers in Composites for Ballistic Applications–A Review	Further research and development to fully integrate coir and other natural fibers into ballistic applications, highlighting their potential in replacing synthetic fibers.	Journal of Natural Fibers
Tiwari N.; Satyam N.; Puppala A.J.	Strength and durability assessment of expansive soil stabilized with recycled ash and natural fibers	Coir fiber when combined with bottom ash (BA), coir fibers help stabilize the soil, improving its mechanical properties like unconfined compressive strength and split tensile strength	Transportation Geotechnics
Naik V.; Kumar M.; Kaup V.	A Review on Natural Fiber Composite Materials in	Emphasizes the role of these materials in reducing vehicle weight and	Engineered Science

	Automotive Applications	improving fuel efficiency, while also providing sustainable alternatives to synthetic fibers.	
Tiwari N.; Satyam N.	An experimental study on the behavior of lime and silica fume treated coir geotextile reinforced expansive soil subgrade	Combined with lime and silica fume, coir geotextiles help reduce swelling and increase the load-bearing capacity of the soil, making it a sustainable solution for reinforcing road subgrades and infrastructure.	Engineering Science and Technology, an International Journal
Karmegam N.; Jayakumar M.; Govarthanan M.; Kumar P.; Ravindran B.; Biruntha M.	Precomposting and green manure amendment for effective vermitransformation of hazardous coir industrial waste into enriched vermicompost	Coir waste, when properly treated, can be sustainably managed and repurposed into a valuable organic fertilizer, reducing environmental hazards and supporting agricultural productivity.	Bioresource Technology
Sathish T.; Palani K.; Natrayan L.; Merneedi A.; de Poures M.V.; Singaravelu D.K.	Synthesis and characterization of polypropylene/ramie fiber with hemp fiber and coir fiber natural biopolymer composite for biomedical application	The study demonstrates the potential of coir fiber in sustainable, natural biopolymer composites for medical purposes.	International Journal of Polymer Science
Sathish T.; Jagadeesh P.; Rangappa S.M.; Siengchin S.	Mechanical and thermal analysis of coir fiber reinforced jute/bamboo hybrid epoxy composites	Highlights coir's role in improving the overall performance of natural fiber-reinforced composites, positioning it as a viable eco-friendly alternative to synthetic fibers.	Polymer Composites
Maroušek J.; Marouškova A.; Periakaruppan R.; Gokul G.M.; Anbukumaran A.; Bohatá A.; Kříž P.; Bárta J.; Černý P.; Olšan P.	Silica Nanoparticles from Coir Pith Synthesized by Acidic Sol-Gel Method Improve Germination Economics	Silica nanoparticles synthesized from coir pith using the acidic sol-gel method enhance seed germination and improve overall agricultural economics	Polymers

Sathish T.; Jagadeesh P.; Rangappa S.M.; Siengchin S.	Studies on mechanical and thermal properties of cellulosic fiber fillers reinforced epoxy composites	Coir, as a cellulosic fiber filler in epoxy composites, contributes to enhanced mechanical and thermal properties.	Polymer Composites
Hariharan A.; Prabunathan P.; Kumaravel A.; Manoj M.; Alagar M.	Bio-based polybenzoxazine composites for oil-water separation, sound absorption and corrosion resistance applications	2020	Polymer Testing

List of the top sponsoring agencies in India for the research in the field of coir.



1. Department of Science and Technology, Ministry of Science and Technology, India
2. Council of Scientific and Industrial Research, India
3. Ministry of Education, India
4. Kerala State Council for Science, Technology and Environment
5. University Grants Commission
6. Department of Science and Technology, Government of Kerala
7. Indian Council of Agricultural Research
8. Science and Engineering Research Board
9. VIT University

10. Department of Biotechnology, Ministry of Science and Technology, India

Industry Challenges

Coir, a versatile and eco-friendly fiber derived from coconut husks, boasts numerous benefits, including durability, biodegradability, and suitability for various applications for the emerging global needs. However, the coir industry is not without its hurdles. It faces production challenges, such as fluctuating raw material quality and seasonal variations, as well as market pressures from synthetic competitors and price volatility. Additionally, the industry must navigate strict regulatory landscapes and adopt sustainable practices to ensure its long-term viability. Addressing these issues is key to unlocking coir's full potential in the global market. The various industries and the stakeholder visited to understand the challenges and needs includes the following

1. Par Coco Products, Udumalai Road, Palani
2. Srivari Coirs, Coimbatore Bypass, Pollachi
3. Bio Gardener, Pollachi
4. AV Coirs, Pollachi
5. AP Industry, Marthandam, Kanyakumari District
6. Ethmozhi Coirs, Ethamozhi, Nagercoil
7. NKP Coirs, Nagercoil
8. Felix Exports, Ethamozhi, Nagercoil
9. Vaigai Coirs, Vadipatti, Madurai
10. Unitek Hydraulics, Chinnavedampatti, Coimbatore.
11. Essar Engineers, Coimbatore
12. Kerala State Coir Machinery Manufacturing Company,Alappuzha
13. Central Coir Research Institute, Alappuzha.

Production Challenges

The coir industry faces several production challenges that impact its efficiency, product quality, and overall growth. These challenges arises from the nature of the raw materials, the processes involved in fibre extraction, and the key challenges in the production includes

Lack of technology

The major challenge is the reliance on traditional, labor-intensive processing techniques, which are less efficient and hinder productivity. There is only a limited access to advanced machinery for the small and medium-sized enterprises (SMEs). The financial constraints prevent these enterprises from investing in automation and more efficient technologies. The traditional retting process used for extracting coir fibers is not only time-consuming but also environmentally problematic, raising environmental concerns and longer production cycle time.

Erratic Climate

Erratic climate conditions have adversely affected the production process, particularly as unseasonal rain disrupts the drying of coir fibers. This inconsistency in weather patterns can lead to delays in production, lower fiber quality, and increased costs for coir manufacturers.

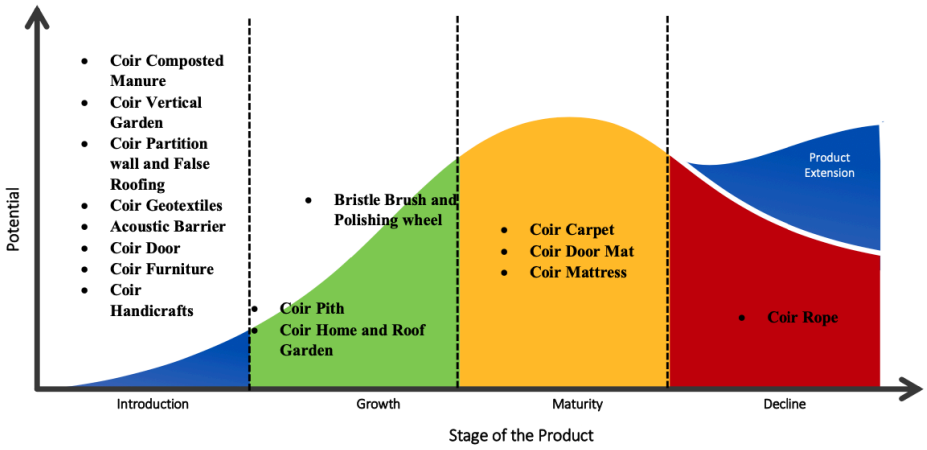
Cost of Production and Price Instability

Small businesses exporting coir and coco pith face challenges due to high production costs and fluctuating prices. Expenses related to labor, the availability of raw materials, and market demand can all impact the overall cost and pricing of these products.

Limited Access to Financial Resources and Credit

Small scale manufacturers and exporters of coir are hindered by a lack of financial resources and difficulty in obtaining credit. This increases the cost of production due to the higher interest rates, inability to have continuous production and difficulty in business expansion.

Market Challenges:

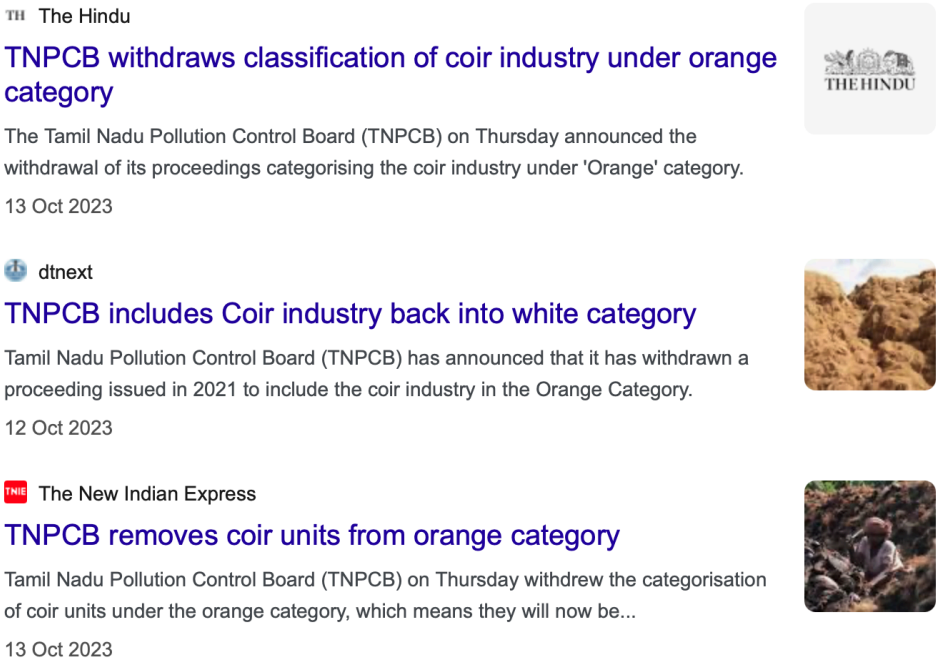


The above figure illustrates the product life cycle of various coir products. Traditional coir products, such as coir rope, coir carpets, coir door mats, and coir mattresses, benefit from well-established technologies, support from common facility centers, and private investments. However, emerging coir products like coir vertical gardens, coir geotextiles, acoustic barriers, and coir furniture face significant industry challenges, particularly in market acceptance, competition from synthetic alternatives, and pricing pressures.

Market Acceptance

The traditional coir products have achieved market acceptance however the competition is high and the profit margin is narrow in these product line up. The newer applications like coir vertical gardens and coir geotextiles are still gaining recognition, For instance, coir geotextiles, which offer a sustainable solution for soil erosion control and soil conditioning, are eco-friendly and biodegradable. Despite their benefits, the adoption of these products is limited due to a lack of awareness and slower acceptance by industries and consumers. The traditional coir products have established presence in the market, and the industry faces significant challenges in promoting newer, more sustainable coir applications.

Regulatory Challenges



The coir industry, like many others, faces several environmental regulatory challenges that can impact its operations, production processes, and overall sustainability. These challenges stem from the need to comply with environmental laws and regulations designed to protect natural resources, reduce pollution, and ensure sustainable practices. Key environmental regulatory challenges related to the coir industry include:

- **Disposal of baby fiber:** The coir production process generates significant amounts of waste, such as coir fibre of shorter length. Proper disposal and management of these byproducts are required to avoid environmental harm. There is a very little R&D for value addition of these fibers and end up disposed as land fills.
- **Management of Retting Waste:** The traditional retting process used to extract coir fibers involves soaking coconut husks in water, which can produce large quantities of organic waste and result in water pollution. Environmental regulations require the treatment of retting effluents before they are discharged into water bodies. The industry lacks a necessary cost effective technology for disposal of the same.

- **Lack of Regulatory Standards / Certifications:** The new innovative products such as coir geotextiles and coir wood currently lack guidance on quality standards, manufacturing processes, quality parameters, certification, and usage. Establishing well-defined standards and codes is essential to ensure consistent product quality, enhance market acceptance, and support the widespread adoption of these sustainable alternatives

Sustainability Challenges:

The coir industry, known for its eco-friendly and versatile products, faces significant sustainability challenges that impact its long-term viability. Managing natural resources effectively, such as water and coconut husks, is essential to ensure sustainable coir production. The extraction and processing of coir need to adopt practices that minimize environmental impact while maximizing efficiency. Additionally, the industry must balance the demand for high-quality, biodegradable products with the need to maintain affordable production costs. Addressing these sustainability challenges is crucial for preserving coir's reputation as a green alternative in various applications.

Research & Development

Research and development (R&D) is the key to ensure the long term sustainability of the industry. Key issues that need to be addressed by the R&D for sustainability include innovative processing technologies to improve fiber quality and consistency, enhance product durability, and develop new applications for coir to expand market reach. Accelerated R&D efforts focused on novel coir products, sustainable production methods, life cycle assessments, and establishing standards and certifications for new coir applications are the need of the hour. These advancements are crucial for the industry to remain sustainable and competitive in the global market. Lack of investment in R&D for sustainable practices makes it difficult to reduce environmental impact while maintaining cost-effectiveness. The collaboration between research institutions and the industry is often limited, hindering the advancement of technology and product development in this sector.

Resource management

Several factors limit the full potential of the coir industry. The inadequate collection mechanisms lead to underutilization, with less than 42% (2018-19) of coconut husks being processed into coir fibre. This represents a significant waste of a valuable resource. This is mainly due to the lack of awareness, lack of incentive for such activities, geographical constraints and lack of an organised system for husk collections. The husk utilisation is expected to improve to 60%, however a cost effective mechanism for the husk collection model is to be developed for 85% husk utilisation. It cannot be underestimated as it will become a problem causing price fluctuation as the world starts adopting coir for various applications.

ENVIRONMENT

Disposal is a challenge as coconut husks pile up across Indian cities amid high summer demand

Tender coconut husk is biodegradable and has extensive uses. But it takes a long time to degrade due to its high moisture content and size.

Ravleen Kaur
May 08, 2024 · 07:30 pm

READ IN APP

Promoting Sustainable Growth: Expanding Coir Industry Across India

The top five states in India for registered coir industries are Kerala (9,244), Tamil Nadu (4,618), Andhra Pradesh (1,000), Odisha (946), and Karnataka (728), with a total of 168,26 registered coir industries nationwide. Being a rural enterprise faces all challenges of the MSME and technology challenge to leverage its export potential, adoption to digital commerce still has to be addressed. Efforts to establish industry by value to coir has to be focused across the other coconut harvesting states.

Leading Coir Industries and Coir Startups

The coir industry, rooted in the sustainable use of coconut husks, has grown significantly, thanks to visionary leaders, innovative exporters, and dynamic startups. These industry leaders have pioneered advancements in coir processing, introduced novel products, and explored new markets, driving growth and sustainability. Let us explore the companies that standout and are leaders in the coir industry, as well as the specific needs and opportunities that can further enhance its development and global impact. The export of coir and coir products has become a significant contributor to the economy, especially in countries like India, where coir production is widespread. Coir exports include a variety of products, such as mats, ropes, geotextiles, and brushes, which are valued for their durability, eco-friendliness, and versatility. Exporters focus on meeting international quality standards to cater to diverse markets worldwide. Despite facing challenges such as competition from synthetic alternatives and fluctuating market conditions, the coir industry continues to grow, driven by increasing demand for sustainable and biodegradable products.

Exporters of Coir & Coir Products - 2022-23
Exporter's Performance during the period from April, 2022 to March, 2023.

Quantity in MT — Value in Rs.Lakhs

Sl.No.	Exporter	Quantity	Value	QTY%	VAL%
1	KERAFIBRETEX INTERNATIONAL PVT.LTD.	19786.80	21317.19	1.56	5.34
2	REMMY SUBSTRATES INDIA PRIVATE LTD.	59564.07	14768.56	4.71	3.7
3	HARISH COCONUT PRODUCTS PVT. LTD.	96049.66	12905.74	7.59	3.23
4	DUTCH PALNTIN COIR INDIA PVT.LTD	33825.98	12186.50	2.67	3.05
5	FIBRE WORLD	8563.45	10066.98	0.68	2.52
6	N C JOHN & SONS LIMITED	7996.99	9817.58	0.63	2.46
7	PALM FIBRE (INDIA) PRIVATE LTD.	6762.71	9570.60	0.53	2.4
8	TRAVANCORE COCOTUFT PVT.LTD.	6965.49	8437.12	0.55	2.11
9	WILLIAM GOODACRE & SONS INDIA LTD	6538.13	7483.80	0.52	1.87
10	FLOOR GARDENS	5969.73	5636.17	0.47	1.41
11	VAIGHAI AGRO PRODUCTS LIMITED	23825.29	5472.34	1.88	1.37
12	ELITE CARBON CREATIONS PVT. LTD.	41115.26	5105.85	3.25	1.28
13	R.L.KHANNA & COMPANY (OVERSEAS)	4070.27	4996.30	0.32	1.25
14	SIVANTHI JOE COIRS	6913.96	4901.34	0.55	1.23
15	PELEMIX INDIA (P) LTD	13061.52	4713.56	1.03	1.18

The leaders in the coir industry are dedicated to advancing both innovation and sustainability while enhancing quality and meeting client needs. They excel in various areas, from production and quality management to market expansion, and are committed to utilizing renewable resources. These professionals focus on improving rural livelihoods, driving integration within their firms, and promoting India's coir sector globally through high-quality products such as doormats. Their combined efforts are steering the industry towards greater growth and development, particularly in

regions like Tamilnadu & Kerala. The leadership factor that enabled the Visionary leader to standout in the global market is listed in the below table.

Visionary Leader	Description
Anandharaju Muthusamy Founder, Anandh International Peat Industries, Maramangalathupatti	An industry expert, highly committed to enhancing the lives of people in rural areas, aligning with the broader goal of contributing to the country's development.
Deepak Mahesh, Vice President, CoirPlus, Pollachi.	With a commitment to innovation, sustainability, and quality, he has established himself as a prominent player in India's coir sector utilizing renewable resources.
Deepika Muthusamy, Co-Founder, Saamy Coir Product, Dindigul.	A pioneer industry expert helps the firm meet specific requirements of individual clients in order to provide them high-quality and best-of-its-class products.
Jitesh Nambiar, Director, Geco Coir Products, Cherthala.	With his unmatched industry expertise, he looks after the production, sampling, quality, and day-to-day communication.
Dr. Pratheesh G Panicker, Managing Director, Coir Craft, Alappuzha	With his unmatched skill and industry expertise, he is steering the coir industry of Kerala to a new level.
Suga Kumaravel, Founder, Sugacoco, Coimbatore.	A highly accomplished professional steering the firm towards upward integration with his extensive industry expertise.
Vinodkumar, Ram Coir Mills, Alleppey.	He is highly engaged in exporting top-quality doormats, especially PVC Doormats and Latex Tufted mats, Jute Poly Propylene Door Mats, and many more through the firm.

Source: Industry Outlook

Anandh International Peat Industries

Anandh International Peat Industries Private Limited is one of the prominent manufacturers of Coco Peat products in India. We are specialised in the manufacturing eco-friendly Coco Peat products for sustainable agriculture, Horticulture, Floriculture and substrates industry usage. We are unique in procuring, producing and marketing Cocopeat products. Our products are guaranteed certain qualities to customers are Eco-Friendly, Bio degradable, Durability, Water retention, Air Porosity, Low maintenance, Long lasting performance.

Our infrastructure is completely equipped with advanced machineries, Software tools, Manufacturing unit, packaging unit and storage facility. we use state of art (or best-in-class) process techniques to maintain standard quality control metrics for all the stages of washing, drying, screening and compressing. We are driven by highly passionate and dedicated workforce. Our ultimate aim is to provide utmost satisfaction to the clients by meeting their expectations.

Coco Green Substrates

Cocogreen Substrates is a leading manufacturer and exporter of high quality Coir pith or Coco peat products from India. We have 25 years of experience in supplying to the Horticulture/Floriculture and Farming/Landscaping applications globally. We are one of the Pioneers of the Coir pith / Coco peat industry with wide presence in USA, Europe, Japan, South Africa, Chile, Korea and Mexico. Our company 'Ravi Bala Exports' is 100% family-owned business and has come a long way since inception in 1994 through our commitment to excellence and innovation. From 1994 to 2014, we have been exporting with the label of 'Ravi Bala Exports' which is a sister concern of Cocogreen Substrates. From the year 2014, we restructured to operate under Cocogreen Substrates with the diversification to meet varied requirements. Main factory is situated in Sivagangai, a municipal area famous for its elegant beauty and green coconut trees. It is in the south of Tamil Nadu, India. We are 45 Kms away from Madurai Airport. Our team have achieved a broad perspective and in-depth technical knowledge in quality management and manufacturing. Enhancement of technology and human capital makes sure that we stay ahead. Our in-house quality control and well-managed export department assures the buyers prompt delivery with competitive prices. We are focused to meet the challenges of globalization by improving quality, achieving cost reduction and enhancing efficiency. Our core strength lies in understanding the customer needs and providing them the solution for their Coir requirements. We manufacture 100 % organic Coconut Coir products from our own

manufacturing facility located in India. Being the manufacturer helps us to offer our customers competitive price all through the year.

Geco Coir Products Private Limited, Kerala.

The word "Traditional" is deeply connected to nature. Before the industrial revolution, traditions guided how people lived, including their clothing, materials, and customs. In Kerala, the coconut tree, or "Keram," has been central for centuries. People utilized every part of it—coconut leaves for roofs, trunks for construction, and the golden coir fiber for doormats, which became world-renowned. GECO Coir Products, established in 2007, continues this heritage by producing eco-friendly products from natural fibers like jute, hemp, and coir, offering sustainable and green solutions globally.

Images of novel coir product currently made by leading industry

KERAFIBRETEX INTERNATIONAL PVT.LTD, KERALA

Established in the year 2000, we are engaged in manufacturing and exporting a wide array of Coir, Jute and Rubber Products. The products offered by us are available in various designs, sizes, shapes and colors. These are designed keeping in mind the aesthetic value of our clients and are widely used in houses, offices and any fashionable place. The products offered by us are also available as per the specification of our clients.

Saamy Coir Products, Tamilnadu.

Saamy Coir Products is a leading manufacturer, exporter, and supplier of cocopeat from Tamilnadu, India, with over 20 years of experience in coconut and coir products. As a second-generation family business established in 2000, we are committed to guaranteeing high quality and best-of-its-class products by strictly controlling the production process in our factories. We are a registered member of The Coir Board of India, the Federation of Indian Export Organisations (FIEO), approved by the Government of India, and an ISO 9001:2015 Certified Company. Our offices are located in India and the USA, and we utilize the latest machinery and technologies along with high-quality raw materials

to produce various blends of coir products. Additionally, we have a 3.5 lakh square feet concrete yard for drying to prevent foreign material contamination.

Travancore Cocotuft Pvt Ltd, Kerala.

Travancore Cocotuft is a leading player in the coir industry, founded as an Indo-German joint venture. Specializing in the manufacturing of Tufted Coir Mats, Woven Jute Rugs, and Moulded Rubber/Polypropylene Mats, the company has grown to become India's largest exporter of doormats, shipping over 2,500 container loads to 85+ countries. Originating from a coir exporting business founded in 1917 by Mr. Velayudhan in Alleppey, the company now stands as a 50-million-dollar group, spanning five generations of family leadership.

Startup: Greenamor, Kochi.

At Greenamor, we believe that the future of packaging lies in sustainability. As stewards of the environment, it's our responsibility to innovate and provide eco-friendly packaging solutions that not only preserve our planet but also meet the stringent demands of the cosmetic, food, and pharmaceutical industries. Our goal is to create eco-friendly packaging that will definitely meet your industrial standards and also helps to preserve our planet. Through extensive research and development, we've crafted environmentally friendly options of compostable containers from waste fibre. Join our mission and let's lead the way to sustainability. Greenamor is taking its initial strides towards sustainability through the development of eco-friendly cosmetic containers. However, our dedicated R&D team is actively seeking opportunities to revolutionize in the field of pharmaceuticals, toys, hospitality, and jewelry packaging in the near future.

Startup: Go Do Good, Pune.

Go Do Good provides custom sustainable packaging solutions to quality & price-conscious individuals and businesses. Acting as a direct replacement for bubble wrap, The Good Bubble Wrap is made from agricultural waste materials like coconut coir and wool waste which offer excellent cushioning properties for fragile products. To source this material, we work with various farmer communities at a grassroots level for ethical sourcing. The Good Bubble Wrap is 100% biodegradable and home-compostable, hence acting as a perfect eco-friendly solution for breakages in logistics.

- 6x higher impact protection
- Reduces manual labour
- Enhances unboxing experience

Coir Industry Needs

Technology Needs of the Industry:

The technology needed for the coir industry focuses on developing advanced machinery and control systems to produce high-quality coir yarn with consistent thickness and minimal hairiness. To achieve this, there is a need for innovation in spinning technologies and automated control systems that enhance yarn uniformity and quality. Such advancements will help improve production efficiency, product consistency, and market competitiveness, ultimately supporting the industry's growth and sustainability.

There is a significant need in the coir industry for advanced drying solutions that utilize renewable energy. Traditional open-air drying methods are heavily dependent on weather conditions, which can lead to inconsistent drying times and variability in product quality. By implementing dryers that operate on renewable energy sources, the industry can create a more controlled and stable drying environment, ensuring uniform moisture levels in coir and coir pith products. This would not only enhance the consistency and quality of the products but also reduce production delays caused by unfavorable weather. Moreover, adopting quick, reliable, and sustainable drying technologies would lower energy consumption, reduce carbon footprints, and contribute to the overall sustainability of coir production, aligning with global environmental goals and improving the industry's competitiveness.

Market Development Need of the industry

Strategies for Market Expansion, Branding, and Marketing

To successfully expand into new markets, the company needs to develop robust strategies that focus on identifying and targeting potential market segments. This includes creating strong branding initiatives to position coir products as sustainable, eco-friendly alternatives to synthetic materials. Effective marketing campaigns should be tailored to highlight the unique benefits of coir, such as its biodegradability, durability, and versatility, appealing to both environmental and quality-conscious consumers. The emerging and aspiring entrepreneur requires training, mentoring and support for their marketing and branding exercise.

Access to International Markets

The coir industry must work towards improving access to international markets by meeting global quality standards and obtaining necessary certifications, such as ISO and eco-labels. Building strategic trade partnerships and participating in international trade fairs and exhibitions can help establish a global presence. Additionally, navigating export regulations and reducing tariffs can make coir products more competitive in the international market.

Consumer Awareness:

Raising consumer awareness about the benefits of coir products is crucial for driving demand. This can be achieved through educational campaigns, workshops, and demonstrations that showcase the environmental benefits and multiple uses of coir products. Collaborating with influencers,

environmental organizations, and industry stakeholders can also help amplify the message and reach a broader audience.

Policy Support

The industry needs to advocate for favorable policies and government support to enhance competitiveness. This includes seeking subsidies for sustainable practices, tax incentives for eco-friendly production, and grants for research and development. Engaging with policymakers to create supportive frameworks can encourage the adoption of coir products both domestically and internationally.

Trademark Protection

Establishing and protecting trademarks is essential for securing brand identity and ensuring the authenticity of coir products in the market. This involves registering trademarks in key markets and actively monitoring for infringement to prevent counterfeit products from undermining the brand's reputation. Protecting intellectual property rights is also crucial for fostering innovation and maintaining a competitive edge in the market.

Research and Development Needs

The R&D in the coir industry should prioritize developing applications that can be quickly brought to market, such as sustainable building materials, automotive components, and agricultural products like biodegradable grow bags and mulches. Efforts should also focus on enhancing coir-based consumer goods and packaging solutions, replacing synthetic materials with coir to reduce environmental impact. By optimizing production processes and improving product quality, the industry can meet the immediate demand for eco-friendly alternatives while boosting economic returns.

However, for long-term success, R&D should explore more advanced and innovative uses of coir, such as in energy storage technologies like supercapacitors, which leverage the carbon-rich properties of coir fibers. There should also be a focus on biomedical applications, where coir's natural antimicrobial and biodegradable characteristics can be utilized for medical implants and wound dressings. Additionally, the development of high-performance textiles and composites, through advanced processing and blending techniques, can open new markets and applications. Long-term

research should aim to create new, high-value coir products that push the boundaries of current technology, ensuring the industry's sustainability and global competitiveness in the future.

Success of Scheme Of Fund For Regeneration Of Traditional Industries (SFURTI)

The coir industry faces a complex challenge. Outdated technology and a lack of skilled workers create a vicious cycle. Traditional methods, while valuable, lead to an aging workforce less interested in innovation. Furthermore, outdated technology and fragmented supply chains, characterized by decentralized processing and weak connections between stakeholders, lead to inconsistent prices. This inefficiency prevents economies of scale, further discouraging investment in modern technology and skill development. The lack of a skilled and innovative workforce, coupled with a fragmented and inefficient supply chain, ultimately hinders the overall effectiveness and competitiveness of the coir industry.

- Outdated technology
- Aging workforce
- Lack of skilled workers
- Fragmented supply chains
- Inconsistent prices
- Lack of innovation

To address these challenges, Scheme Of Fund For Regeneration Of Traditional Industries (SFURTI) was launched in 2005 by the Ministry of MSME. It aims to revitalize traditional industries like coir. It envisions a multi-pronged approach to enhance competitiveness through market focus, productivity improvements, and profitability. The scheme, managed by the Coir Board, establishes Common Facility Centers within clusters to provide modern technology and infrastructure. To encourage innovation, Product Development and Design Intervention Centers foster the creation of new and improved coir products. Market promotion efforts and dedicated outlets within clusters aim to increase consumer awareness and improve access to coir products. Overall, the SFURTI scheme seeks to develop clusters, strengthen local governance with stakeholder participation, and bridge the gap between traditional skills and modern advancements, ultimately leading to the regeneration of the coir industry and creation of sustainable employment opportunities.

STATE	NAME OF THE CLUSTER	No of Clusters
Karnataka	Tumkur, Kumta, Haralakatta, Javagal, Cheluru, Kadaluru, Korategere, Sri Gavi Ranganatha Swamy	8
Kerala	Neyattinkara, Balusseri, Haripad, Ambalapuzha	4
Gujarat	Samvedana, Tarapur	2
Maharashtra	Pendur, Sawantavadi	2
Tamil Nadu	Dindigul, Kangayam (Thirupur), Palladam, Thirunelveli Salem Consortium (Mettur), Dharmapuri Coir Cluster, Madurai Coir Cluster, Pollachi Coir Cluster, Ethamozhy, Krishnagiri, Pakkam, Kongu, Mannargudi, Salem (Omalur)	14
Andhra Pradesh	Vizianagaram, Kadiyapulanka, Amalapuram	3
Odisha	Bhograi, Konark, Rajkanika, Raghunath, Radharani	5
West Bengal	PurbaBardhaman	1
UT of Andaman	Andaman	1
TOTAL NUMBER OF CLUSTER		40

The SFURTI scheme directly addresses several challenges of the coir industry by establishing Common Facility Centers (CFCs) within clusters. The CFCs are equipped with modern technology, potentially attracting a younger workforce and reducing reliance on outdated methods. Cluster development fosters collaboration, improving supply chain efficiency and reducing price inconsistencies. Product Development and Design Intervention Centers directly address the innovation gap by encouraging creation of new, high-value coir products. This multi-pronged approach, encompassing infrastructure development, skill development, innovation, and market promotion, contributes to an overall improvement in the industry's effectiveness and competitiveness. The economies of scale achieved through cluster development has supported lower production costs and more competitive pricing The SFURTI has successfully developed 40 clusters across the country. Tamil Nadu and Karnataka attracted the majority of the cluster. Although successful in solving

multiple problems of the industry such, the implementation of only 40 CFCs in 18+years is quite slow. It is ripe time to identify potential states for further implementation of more CFCs.

Strategic Recommendations for the Coir Industry

Infrastructure Development:

Establish dedicated husk collection centers across coconut-producing regions to increase the utilization of raw materials and enhance the overall supply chain efficiency for coir production.

Incentive and Subsidy Schemes

Introduce incentive schemes to boost the export of coir products, along with subsidies specifically targeted at promoting the novel coir products. This can encourage more investments and innovation in coir-based products, making them more competitive globally.

Government Procurement Policy

A clear procurement policy that encourages government and public sectors to use coir products is to be mandated. This could involve setting targets for coir usage in various applications, thereby ensuring steady demand and supporting local producers.

Establishment of Standards

Develop and enforce standardized codes for products like Coir Geotextiles, Coir Wood, and other coir-based materials. This will help build trust among consumers and facilitate broader adoption of these products in various industries.

Enhanced Marketing and Awareness

Increase publicity for new-generation coir products such as horticultural items, geotextiles, and coir wood. Greater awareness can be achieved through participation in international exhibitions, targeted marketing campaigns, and leveraging foreign embassies to promote coir in new markets.

Training and Development Programs

Organize more training programs for new coir entrepreneurs across different regions to build capacity and innovation in the industry. This will help in nurturing new talent and spreading knowledge about advanced coir production techniques.

Workforce Welfare Schemes

Introduce special welfare schemes for coir workers to retain and attract new talent to the industry. This could include health benefits, educational programs, and financial incentives to ensure a stable and motivated workforce.

Financial Support and Credit Facilities

Implement an interest subsidy scheme for bank loans to large-scale coir producers and exporters, along with a structured credit plan to support the establishment of new coir units. Aimed at encouraging industry growth, these financial aids should be accompanied by annual export targets to stimulate continuous improvement and expansion.

Stakeholder Engagement and Innovation

Foster a sense of commitment and responsibility among industry stakeholders to maintain high-quality production standards and to continuously innovate. Regular consultations with importing countries, industry experts, and consumers can help understand evolving market demands and align product development accordingly.

Conclusion & Way Forward

The coir industry is a vital segment of India's MSME sector, playing a significant role in employment generation and socio-economic development. With its eco-friendly products and wide-ranging applications, coir offers sustainable solutions to pressing global environmental issues. To fully realize the potential of coir, there is a need for focused policy support that accelerates R&D, ensures quick and adequate funding, and empowers rural communities through improved infrastructure and training.

By investing in these areas, the coir industry can enhance exports, contribute significantly to GDP growth, and promote sustainable development on a global scale.

Moving forward, the industry should prioritize innovation in coir applications, expand into new markets, and strengthen its domestic presence. By leveraging government schemes and enhancing awareness of coir's benefits, the sector can tap into new opportunities, ensuring its growth and sustainability. A concerted effort to enhance product quality, increase consumer awareness, and promote the environmental benefits of coir will be key to transforming the coir industry into a major economic contributor while fostering a greener planet.

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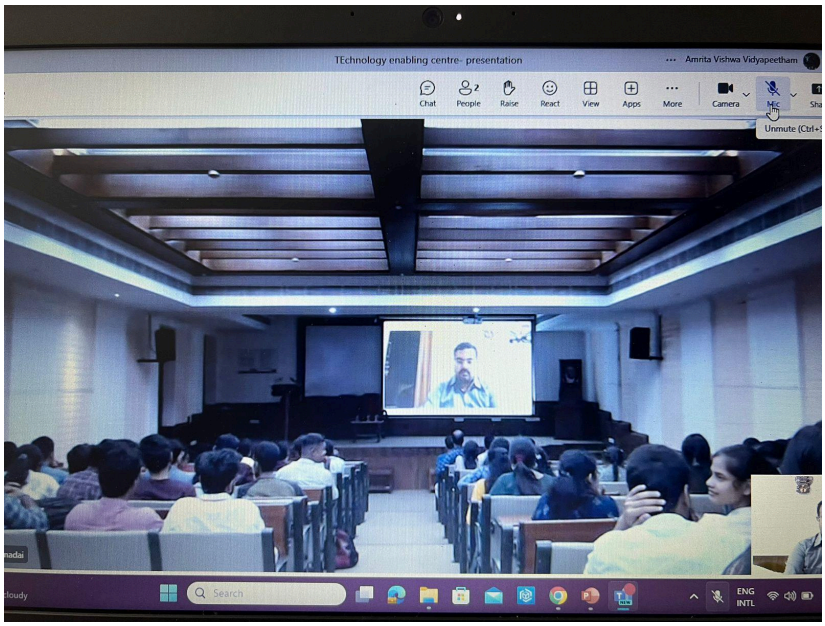
Events, Training Program & Webinars Organised

1. Awareness session on Technology Commercialization Initiatives at NCRTST-2024

A National Conference on Recent Trends in Science and Technology (NCRTST - 2024) was organised on July 1 & 2, 2024 at Amrita Vishwa Vidyapeetham Coimbatore campus. Dr.Prashanth Nair, DST-Amrita Technology Enabling Centre (TEC) fellow and Head, IQAC delivered and presentation on the Technology Commercialisation activities by the centre and the services provided by the center to enable technologies and create an ecosystem for pre-incubation activities for technology development.



2. TRL Awareness program conducted at KPR Institute of Engineering & Technology.

A Seminar was organised on Technology Readiness Levels (TRL) and Importance of Project Mapping for the faculty members of KPR Institute of Engineering & Technology. Dr. Prashant Nair, DST-Amrita Technology Enabling Centre (TEC) fellow and Head, IQAC delivered the session to the participants. Over 50 faculties were benefited by the session.

3. Online Training Program organised for Industries, Faculties and Students.

Amrita Technology Enabling Centre (TEC) successfully organized training programs for industry professionals, faculty, and students, focusing on cutting-edge technology trends in blockchain security and generative AI. These sessions aimed to equip participants with practical knowledge and insights into emerging technologies and their real-world applications.

In one of the webinars titled “Advancing Blockchain Security: The Role of Run-Time Verification in Smart Contract Assurance,”held on September 30, 2024, Dr. Jinesh M.K., Assistant Professor (Sr. Gr.), School of Computing, Amritapuri, shared insights on enhancing blockchain security through run-time verification in smart contract assurance. Key topics included secure smart contracts, real-time issue detection, evolving blockchain environments, and boosting dApp reliability. The session highlighted strategies to address vulnerabilities in blockchain systems and optimize performance in decentralized applications.

Another insightful webinar titled “A Sneak Peek at the Rise of Gen AI and What It Means for Businesses,” held on July 8, 2024, was led by Dr. H. Jyothilakshmy, Assistant Professor, Department of Commerce and Management, School of Arts, Humanities, and Commerce, Amritapuri. The session focused on opportunities and challenges presented by Generative AI, along with the importance of responsible and inclusive adoption of AI technologies to shape a better future for businesses.

Both sessions provided a comprehensive understanding of critical technological advancements, fostering an environment for collaboration, knowledge sharing, and skill development. Through these initiatives, Amrita TEC continues to empower industry stakeholders, educators, and students, enabling them to stay at the forefront of technological innovation and bridge the gap between academia and industry.

4. International Conference on Tsunami Risk Reduction and Resilience

The International Conference on Tsunami Risk Reduction and Resilience (ICTR3) 2024 brought together global experts, researchers, and policymakers to commemorate the 20th anniversary of the 2004 Tsunami. DST Amrita Technology Enabling Centre facilitated panel discussions, workshops, and technology presentations focused on fostering knowledge sharing, innovation, and international collaborations to build a safer and more resilient future. The conference covered key themes, including Early Warning & Emergency Response, Tsunami Preparedness & Mitigation, Psychosocial Impact of Disasters, Ocean and Coastal Ecosystems, Case Studies & Best Practices,

and Resilient Coastal Communities. Serving as a vital platform for international stakeholders, the event aimed to advance tsunami risk reduction strategies and resilience-building efforts through cutting-edge technologies, research, and policy discussions.

Industry-Academia Meet

1. Pravichi at Kottayam District

Amrita Technology Enabling Center (TEC) funded by Government of India's Department of Science & Technology (DST) and headed by Dr. Krishnashree Achuthan, Dean, Amrita Vishwa Vidyapeetham has signed an MoU for academic - nodal partnership with Saintgits College of Engineering (Autonomous), Kottayam, Kerala on 25 June 2024. As nodal partner of the district, an industry academia meet was organised with the support of Confederation of Indian Industry (CII), Kottayam Zonal council as part of the event. Mr. Philip Thomas, Chairman, CII zonal council and representatives from various industries and MSMEs such as Kelachandra Machines, Bioway Packs etc. presented their problem statements, skilling requirements, and requested for solutions and support from this partnership. Innovations of the

college were displayed in the event and evaluated for Technology Readiness Levels (TRL) by the Amrita TEC team. These innovations developed by students include Smart Waste Segregation Unit, Motorized Winch Sling Pull Standing Assistive Device and Exoskeleton for People with Muscular Dystrophy, IoT based tray dryer, Smart cooling system, Shock Stabilised Medicine Cooler etc.

2. Pravichi at Perumbavoor Ernakulam District

DST- Amrita Technology Enabling Center in association with the GEnxmy organised an awareness program Pravichi 2024 on 29 June 2024 for the technology enablement ecosystem that is created to enable technology creation for the industries. The technology industries representatives from the district were given an orientation on the various activities of the Technology Enabling Center. The problem statement of the industries were discussed in the sectors of rubber, plywood and industrial automation.

3. Industry Academia Training Program on Transforming Indian Textile Industry

Amrita Technology Enabling Centre in association with Tiruppur Exporters Association (TEA), Fairtrade India, Centre for Social Markets (CSM) and ASU organised an program on "Transforming Indian Textile Industry" with a focus on technology commercialization, sustainability, and circularity on July 19, 2024 Friday at Padmashri Dr. A. Sakthivel Auditorium, Tiruppur Exporters Association Office, Tiruppur. Shri. Kumar Duraiswamy Joint Secretary, TEA welcomed the participants and Mr. R. Gopalakrishna, Founder Chairman, Royal Classic Mills inaugurated the event and delivered the inaugural address. Dr. P. Balasubramanian set the picture in the participants minds with an opening remark and the significance of the event. The participants were engaged through Collaborative Ideation and Team Exercises by the resource persons. The participant had an holistic understanding of the pressures and challenges in the industry. The various Strategies to integrate sustainability and circularity with innovative ideas and collaborative solutions were developed

through teamwork. The event served as a platform to Collaborate with industry peers and Share ideas, technologies and best practices for Co-creating solutions to transform businesses and the textile industry.

4. Ecosystem awareness program at VDP, Thrissur.

Amrita Technology Enabling Centre (TEC) participated in the two-day Vendor Development Programme organized by the MSME Development and Facilitation Office (MSME DFO) under the Ministry of MSME, Government of India, on December 4, 2024, at the Golden Jubilee Hall, MSME DFO, Thrissur. The event brought together approximately 400 Micro and Small Enterprises (MSEs) and 30 Public Sector Undertakings (PSUs). During the program, Amrita TEC conducted a session detailing its state activities and initiatives aimed at fostering an ecosystem for technology development and how TEC's are creating the ecosystem nationwide. This engagement facilitated networking, knowledge sharing, and the establishment of partnerships among

MSMEs, academia, and PSUs, thereby supporting and promoting the growth of small businesses.

5. Symposium on Technology Transfer, Commercialization & Innovations for MSMEs in the Era of Sustainability and AI

The DST-Amrita Technology Enabling Centre (TEC), in collaboration with the Amrita School of Business, Amritapuri, and the Centre for Management Development (CMD), Trivandrum, successfully organized a symposium on "Technology Transfer, Commercialization & Innovations for MSMEs in the Era of Sustainability and AI." The event convened key stakeholders from academia, industry, and government to explore how MSMEs can leverage technology for sustainable growth. Distinguished speakers emphasized AI integration for intelligent decision-making, cost efficiency, and market expansion. Government officials highlighted the importance of climate resilience technologies, disaster management solutions, and microclimate monitoring. Panel discussions focused on simplifying intellectual property (IP)

transfer, strengthening industry-academia partnerships, and utilizing government support programs such as the MSME Cluster Development Program. Experts from the defense and coir sectors presented industry challenges and potential MSME contributions. The event fostered meaningful collaboration and knowledge exchange, reinforcing DST-Amrita TEC's role in facilitating technology adoption and commercialization for MSMEs. The symposium concluded with a strong commitment to furthering innovation-driven MSME growth through strategic partnerships and capacity-building initiatives.

6. Pravichi TEC Ecosystem Awareness Program in Collaboration with Junior Chamber International

The DST-Amrita Technology Enabling Center (TEC), funded by the Government of India's Department of Science & Technology (DST), organized a TEC ecosystem awareness program – Pravichi, in collaboration with Junior Chamber International (JCI) to foster industry-academia partnerships and

promote technology-driven innovation across various industrial sectors. The event brought together entrepreneurs from diverse industries, providing them with insights into the technology enablement ecosystem, innovation commercialization, and collaborative opportunities available through Amrita TEC. Discussions focused on industry-specific challenges, emerging technology needs, and opportunities for integrating advanced solutions in manufacturing, automation, and sustainability. Amrita TEC highlighted successful industry collaborations in sectors such as coir, cashew processing, and agricultural mechanization, showcasing how technological interventions have improved productivity, efficiency, and market reach. Participants explored avenues for leveraging TEC's expertise in technology scouting, prototype development, and funding facilitation to address sector-specific challenges and drive industrial growth. The event reinforced Amrita TEC's commitment to empowering MSMEs, startups, and established enterprises by bridging the gap between industry needs and research-driven innovations.

7. Pravichi TEC Ecosystem Awareness Program in Collaboration with Bharathiya Kissan Sangh - Keralam at Palakkad

The DST-Amrita Technology Enabling Center (TEC), funded by the Government of India's Department of Science & Technology (DST), organized an TEC ecosystem awareness program - Pravichi, in Palakkad in collaboration with Bharathiya Kissan Sangh - Keralam to address technology requirements in agriculture and agricultural processing equipment. The event aimed to foster a technology enablement ecosystem by connecting industry stakeholders with innovators and researchers to develop technology-driven solutions for the agricultural sector.

The program featured discussions with farmers, agro-industrial representatives, and technology developers on key challenges and emerging needs in precision farming, mechanized harvesting, post-harvest processing, and value-added agricultural product development. Participants highlighted specific problem statements related to automation in farm operations, sustainable irrigation techniques, and cost-effective processing equipment. Amrita TEC provided insights into technology commercialization, industry-academia collaboration, and funding opportunities for developing scalable agricultural solutions. The event reinforced Amrita TEC's commitment to bridging technology gaps and driving innovation in the agricultural sector through strategic partnerships and knowledge exchange.

Events

1. Amrita TEC's Engagement at IBM Gen-AI Conclave

Amrita TEC participated in IBM Gen-AI conclave or engagement and connected with various stakeholders for TEC activities. The two-day international Gen AI Conclave, organised by Kerala State Industrial Development Corporation Ltd in collaboration with IBM, was inaugurated by Chief Minister Pinarayi Vijayan. The provided a platform for academia, industry leaders, and policymakers to explore the transformative potential of Generative AI. Through various sessions and discussions, Amrita TEC gained valuable insights into the latest advancements in Generative AI, its scalability across sectors, and the importance of government initiatives in fostering AI ecosystems.These experiences are poised to enhance Amrita's research initiatives, academic programs, and collaborative efforts in the field of Artificial Intelligence.

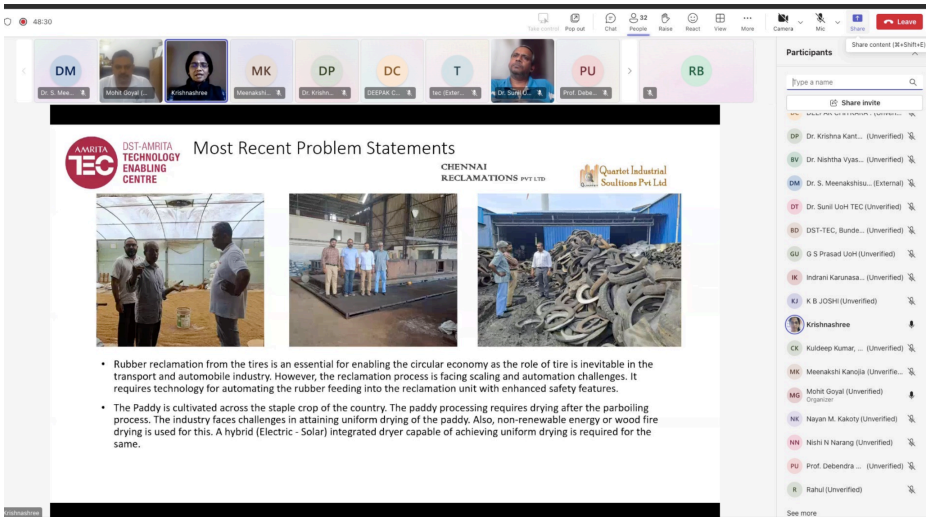
2. Participation in RENERGY Coimbatore 2024

Amrita Technology Enabling Centre (TEC) actively participated in RENERGY Coimbatore 2024, held at the Codissia Trade Fair Complex. The event focused on renewable and sustainable energies, providing a platform for professionals across various sectors to discuss innovations in energy production and storage solutions. Amrita TEC's engagement facilitated valuable networking opportunities, fostering the development of the technology ecosystem through interactions with industry experts and stakeholders.

3. Participation in the TEC Cross Talk

Amrita Technology Enabling Centre (TEC) participated in the DST TEC Cross Talk Series organized for Phase I TECs on 3rd August 2024, focusing on collaborative technology development. Innovators presented waste management technologies, which were explored for potential collaborations. Dr. Krishnashree Achuthan, Director of DST Amrita TEC, presented MSME problem statements and ongoing technological developments. All participating

TECs shared their respective problem statements and technology needs, fostering a platform for healthy discussions aimed at advancing technology development.

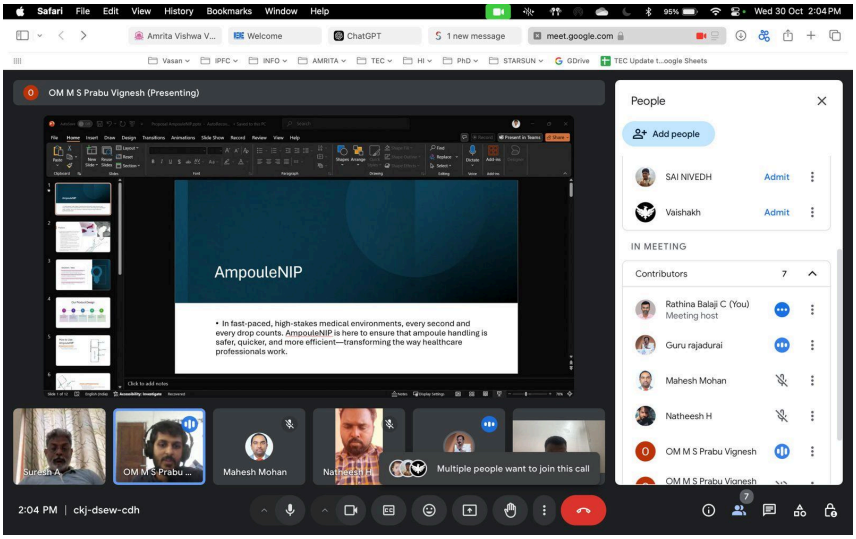


4. Amrita TEC Hosted Programme Advisory Group Meeting with Key TEC Stakeholders.

Amrita Technology Enabling Centre (TEC) organized a hybrid Programme Advisory Group (PAG) meeting on 21st September, 2024, with stakeholders participating both online and offline. Dr. Krishnashree Achuthan, Director of Amrita TEC, presented the center's activities. The meeting was attended by Dr. B. Gurumoorthy, Professor at the Indian Institute of Science,

Advisor to Amrita TEC , Dr. Venkat Rangan, Vice-Chancellor of Amrita Vishwa Vidyapeetham; Shri G. S. Prakash, Director of MSME-DI, Thrissur; Dr. Devarajan, Senior Vice President of TVS Motor Company and Immediate Past President of Bangalore Chamber of Commerce (BCIC); Mr. Narayana Pillai, President of Desinganadu Cashew Processors Association and Laghu Udyog Bharati; Mr. Suresh Kumar T. O., Managing Director of MAKS Automation and Joint Secretary of Laghu Udyog Bharati; Mr. Sumeet Bahl, Vice President of AEPL Pvt Ltd; Mr. Kiran Vijay, Director of KVEES Foods & GenXmy; and Dr. Vivek Shaw from the Central Coir Research Institute (CCRI). During the meeting, collaborations were discussed, including the development of robotic systems and automation technologies with MAKS Automation, and partnerships in IoT and AI with companies like GenXmy for educational applications. Dr. B. Gurumoorthy, Professor at the Indian Institute of Science, proposed creating a white paper on mechanization in the cashew industry, focusing on employment and labor-intensive processes. He also appreciated DST Amrita TEC's work in the coir sector and encouraged exploring industrial applications like structural members, noise barriers, and fire-retardant products. Additionally, he emphasized the importance of highlighting Amrita faculty involvement in ongoing projects to increase engagement with industry collaborations. During the event, MoU's for collaborations, technology development were signed with M/S MAKS Automation Private Limited, M/S Kveess Food Private Limited and M/S Kalpa Agro Private Ltd.

5. Technology Assessment through MSME Hackathon 4.0



The MSME Idea Hackathon is an initiative by the Ministry of Micro, Small, and Medium Enterprises (MSME) in India, designed to foster innovation and support the development of new ideas within the MSME sector. Aligned with this objective, the Amrita Technology Enabling Centre (TEC) has been actively involved in nurturing innovative solutions to address industry challenges. Amrita TEC has facilitated the development of over 16 innovative ideas, providing guidance and support to technology enthusiasts aiming to solve industry-specific problems. The ideas were assessed by the Amrita TEC team, along with experts such as Mr. Suresh Appukuttan (Academic Expert) and Mr. K.C. Gurusamy (Industrial Expert), ensuring a comprehensive evaluation process. The assessment focused on several key parameters: Innovation and Novelty, Feasibility and Practicality, Economic Viability, Scalability and Sustainability, Social Impact, and Technical Competence. Competent ideas stand to receive funding of up to ₹15,00,000 per project, facilitating the transformation of innovative concepts into viable solutions. Through these efforts, Amrita TEC contributes significantly to the MSME Idea Hackathon's mission of enhancing productivity and competitiveness among MSMEs by fostering a robust ecosystem for technology development

6. Participation in TEC Connect & Convergence, Bhubaneswar.

Amrita Technology Enabling Centre (TEC) actively participated in the TEC Connect & Convergence event organized by KIIT Technology Enabling Centre (KIIT-TEC) at KIIT University, Bhubaneswar. This symposium served as a collaborative platform, bringing together academia, industry, and government stakeholders to address technological challenges and explore innovative solutions. During the event, Amrita TEC engaged in discussions focusing on

defense technology requirements, corporate social responsibility (CSR) initiatives, and investment opportunities. Key defense needs highlighted included counter-unmanned aerial vehicle systems, advancements in drone technologies incorporating artificial intelligence, development of smart munitions, and high-power laser directed energy systems. CSR discussions centered on waste management solutions, water body rejuvenation, human-animal conflict management, and self-cleaning mechanisms for solar panels. Investor interactions emphasized support for early-revenue-stage projects across various sectors, with investment ranges between ₹50 lakh to ₹8 crore.The forum facilitated networking with TECs across the country, enabling the exchange of best practices and collaborative strategies to enhance the technology development ecosystem.

7. Amrita TEC exhibited a campaign at the Vendor Development Program, Thrissur.

Amrita Technology Enabling Centre (TEC) actively participated in the two-day Vendor Development Programme organized by the MSME Development and Facilitation Office (MSME DFO) under the Ministry of MSME, Government of India, held on December 4, 2024, at the Golden Jubilee Hall, MSME DFO, Thrissur. The event witnessed the participation of approximately 400 Micro and Small Enterprises (MSEs) and 30 Public Sector Undertakings (PSUs). During the program, Amrita TEC set up an exhibition stall, providing a platform to network with MSMEs and spread awareness about the TEC ecosystem, fostering collaboration, knowledge sharing, and engagement for technology-driven growth in the MSME sector.

8. Amrita TEC promotional activities in the IIIE 2024 exhibition.

Amrita Technology Enabling Centre (TEC) successfully organized an outreach activity by exhibiting a stall at the India International Industrial Expo (IIIE) 2024, held from December 13 to 15, 2024, at the KINFRA International Exhibition Cum Convention Centre, Kochi, Kerala. The expo, organized by the Kerala State Small Industries Association (KSSIA) in collaboration with Metro Mart, featured over 300 exhibitors and attracted more than 10,000 trade visitors, including industry professionals, decision-makers, and business collaborators. Inaugurated by Kerala Chief Minister Pinarayi Vijayan on December 14, 2024, the expo focused on advancements in machine tools, manufacturing technology, automation, and technologies beyond Industry 4.0. Amrita TEC's stall served as a platform to showcase its ecosystem, ongoing projects, and technology-driven solutions, fostering networking opportunities and facilitating discussions with stakeholders for collaborations in technology development. The outreach activity highlighted Amrita TEC's commitment to bridging the gap

between research and industry applications while promoting innovation and sustainable practices in emerging sectors.

9. Interactions with Cochin Shipyard Limited for technology interventions in Disaster Management

Amrita Technology Enabling Centre (TEC) facilitated CSR projects with Cochin Shipyard Limited (CSL), focusing on environmental sustainability initiatives. The projects were officially launched by Shri Madhu S. Nair, Chairman and Managing Director (CMD) of Cochin Shipyard Limited. Dr. Krishnashree Achuthan, Director of Amrita Technology Enabling Centre, actively participated in the event and led discussions on technology interventions for natural disaster management, particularly in regions prone to landslides. Highlighting that Kerala records the highest incidence of landslides in the country, Dr. Krishnashree emphasized the critical need for early warning systems to prevent disasters and minimize loss of life and property. She cited the recent Wayanad landslides as examples where such systems could have made a

significant difference, outlining ideas for advanced warning technologies and community-based resilience systems. The collaboration aims to harness technology and innovation to address environmental and disaster-related challenges effectively, fostering a safer and more sustainable future for vulnerable regions.

10. Interaction with European Union Delegate for collaborations for technology transfer and commercialisation.

A European Union delegation visited Amrita Vishwa Vidyapeetham's campuses in Kochi and Amritapuri on December 2 and 3, 2024, to explore collaboration opportunities in research, education, and innovation. Led by Mr. Pierrick Fillon-Ashida, First Counsellor and Head of Research & Innovation at the European Union Delegation to India, the discussions focused on building partnerships in artificial intelligence, renewable energy, healthcare, and sustainability, with an emphasis on funding opportunities through platforms such as the Enterprise Europe Network (EEN) . During the visit, the delegation also met with Mata Amritanandamayi Devi, Chancellor of Amrita University, at the Amritapuri Ashram, where they exchanged ideas on sustainability, humanitarian efforts, and shared values.

Dr. Krishnashree Achuthan, Director of Amrita Technology Enabling Centre (TEC), actively engaged in discussions during the visit. She emphasized Amrita TEC's interest in exploring collaborations for technology commercialization and technology transfer through EEN, leveraging its network across 56 countries. The discussions highlighted collaboration potential in sustainability, women's empowerment, food, textiles, digital innovation, and artificial intelligence. Amrita TEC aims to utilize cross-border partnerships, enhance technology commercialization strategies, and foster collaborative research and development initiatives with European partners, contributing to global technological advancements.

11. Amrita TEC and Barani Hydraulics Explore Strategic Collaboration for Technological Innovation and Sustainability

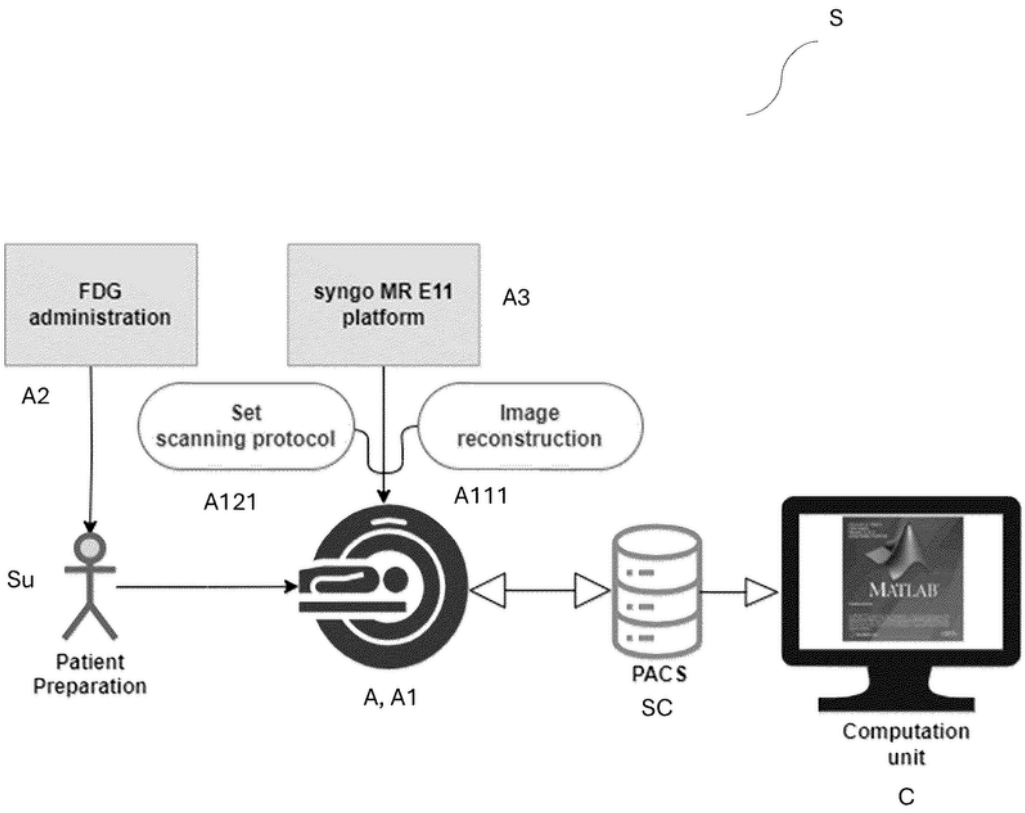
A productive discussion was held with Mr. T. K. Karupannaswamy, Managing Director of Barani Hydraulics, where Dr. Krishnashree Achuthan, Director of Amrita Technology Enabling Centre (TEC), and Dr. Sasangan Ramanathan, Dean & HoS, School of Engineering, Coimbatore, actively participated. Mr. Karupannaswamy provided an in-depth presentation on Barani Hydraulics' journey, highlighting its unique Servo Hydraulic Technology, 50% market share in India, and contributions across 145 industry sectors, including their patented High-Pressure High-Temperature diamond-making machine and self-learning AI-enabled ceramic industry machinery. During the discussions, key areas of collaboration between Amrita and Barani Hydraulics were explored, including Coconut Climber, Coir Industry for Carbon recover and Packing Material, Cashew Processing, Waste to Wealth initiatives, indigenous biomedical machine development, non-invasive cardiology for children, early-stage pancreatic cancer detection, and virtual lab collaborations. A further meeting is to be set up for exploring further possibilities in waste-to-wealth and coconut climber technologies, and connecting IoT and AI startups within the Amrita

ecosystem to Barani Hydraulics. The meeting laid the foundation for a robust partnership aimed at driving technological innovation, sustainability, and industrial advancements.

Patents & Designs Granted through TEC

1. System and a Method Thereof for Automatic Detection of Epileptogenic Focus in Pharmacoresistant Epilepsy

The present invention introduces a system (S) and method for automatic detection of epileptogenic focus (EF) in pharmacoresistant epilepsy using an asymmetry index in FDG-PET images. The system (S) comprises of an acquisition unit for capturing FDG-PET scans and simultaneous whole-brain MRI images, a storage and communication unit for managing the acquired data, and a computation unit for processing and generating asymmetry index (AI) images. The method of the present invention comprises of a novel technique, PET asymmetry after anatomical symmetrization coregistered to MRI (PASCOM), to the AI images and is independent of healthy control PET data, facilitating implementation and multicenter translation. The method is effective in localizing the epileptogenic zone, especially in MRI-negative patient (Su), and can detect epileptogenic focus (EF) independently.



Overview of the system (PASCOM) of the invention.

2. IoT Based Dynamic Risk Assessment in Intelligent Building

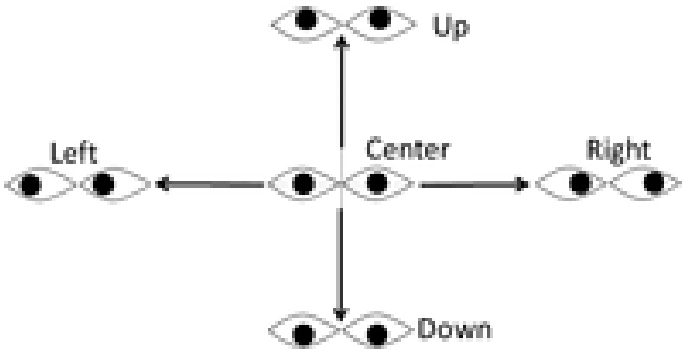
A cloud-based, three-layered IoT-enabled, dynamic assessment and prediction system RAIB (Risk Assessment in Intelligent Building) in an intelligent building (IB) is disclosed, comprising of Risk assessment module I (RAIB-I), capable of assessing the risk based on the primary risk factors (fp1, fp2, fp3, . . . fpn) obtained from multiple users (q1, q2, q3, . . . qn) in the said building, and Risk assessment module II (RAIB-II), capable of assessing the risk factors based on the secondary risk factors (fs1, fs2 . . . fsn) of the said multiple users (q1, q2, q3, . . . qn). Prediction of future risk is done by prediction-based model using the historical risk

assessment data. The Cloud layer (CL) deployed with RAIB and risk prediction module is used for performing the two-phase risk assessment, RAIB-I and RAIB-II and risk prediction from the stored historical data (HD).

3. Sternal Bridge

A sternal bridge has a contiguous panel having a first length and a first height, a first U-shaped notch of a second height less than the first height and a first depth on one end of the contiguous panel, a second U-shaped notch of the second height and the first depth on an opposite end of the contiguous panel, a concave shape on a lower surface of the contiguous panel, and a first through hole passing from the lower surface of the panel through both sides of the first U-shaped notch, and a second through hole passing from the lower surface of the panel through both sides of the second U-shaped notch, the first and second through holes enabling the sternal bridge to be sutured onto the chest wall on either side.

4. Eye Sign Language Communication System



An Eye Sign language communication system and method is useful for people suffering from Quadriplegia, stroke or paralysis. The Eye Sign language communication system is based on advanced machine learning and deep learning to identify the eye sign language based on the eye blinks and direction of eye gaze with help of pupil for interpretation of signs into alphabets and words and conversion of words into speech. Hardware with sensors, controllers, and speakers along with a display screen are used to process the eye signs and display the alphabets, words and sentences and announce the detected alphabets, words and sounds using the speakers.

5. Electrospun Microfibrous Porous Stretchable Membranes and the method of preparation thereof

The present invention discloses a highly stretchable matrix, comprising a mesh of lattice structures of microfibrillar filaments, having a pore size enlargeable up to 8 times by moving the microfibrillar filaments perpendicular to their longitudinal axis without losing integrity. The invention also pertains to a method of preparing said highly stretchable matrix, including:

1. Electrostatic spinning of the polymeric solution into microfibers.
2. Creating an air-flow at the inter-phase of the microfibers to completely eliminate the solvent from their surface, avoiding inter-fibrillar bonding after collection.
3. Dispersing the microfibers perpendicularly to their longitudinal axis, 6-12 times the original width using a dispersion unit to obtain a stretch-responsive fibrillar matrix.

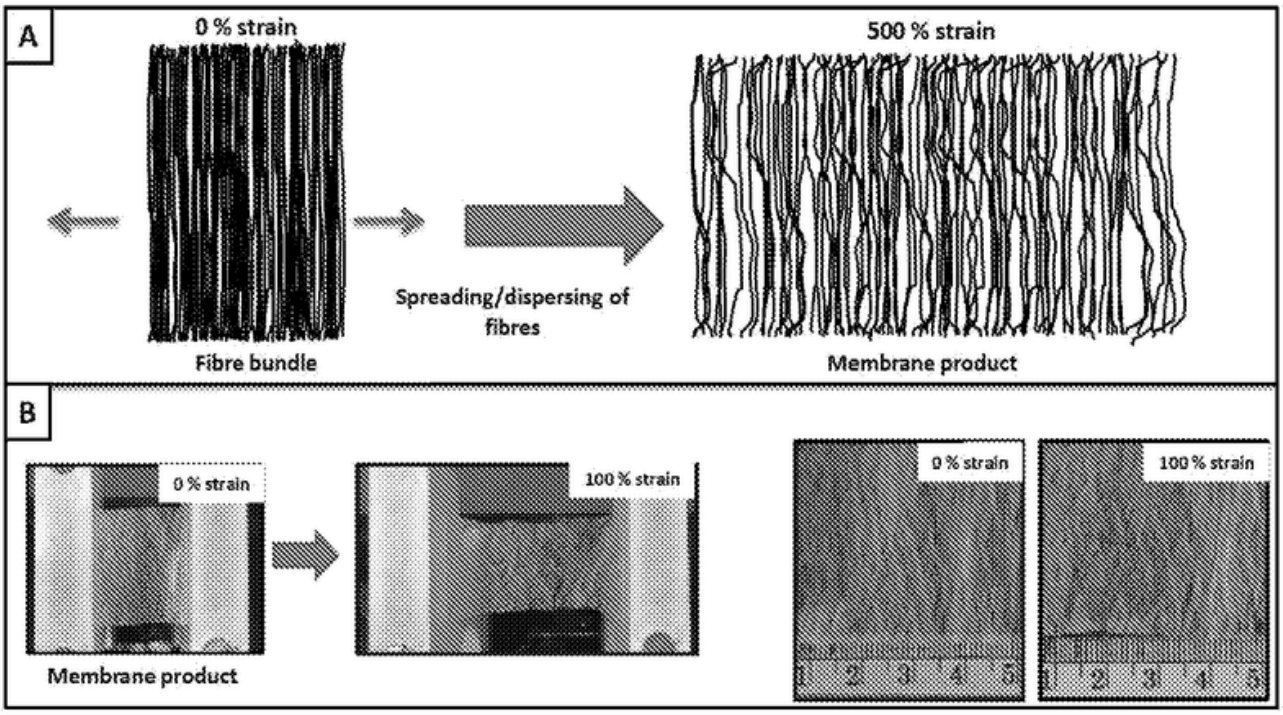


FIGURE 3

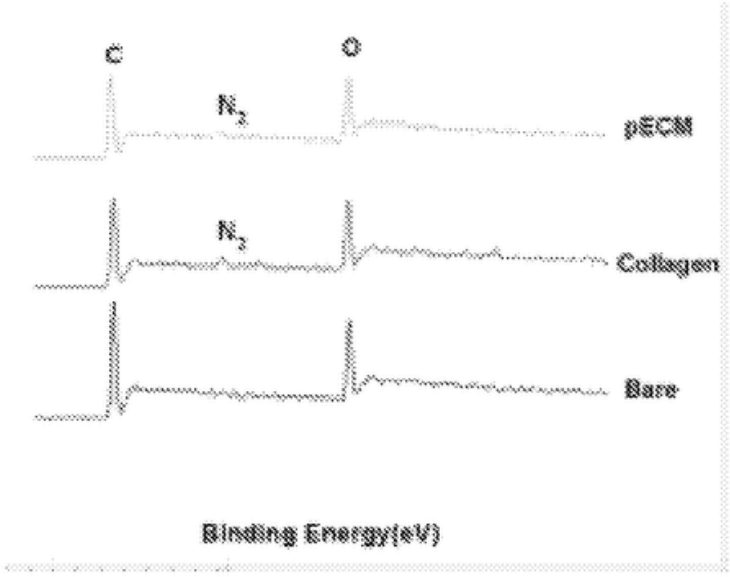


FIGURE 4

Table 4:- List of patents facilitated by Amrita Technology Enabling Center.

Patent Number	Title	Granted In
20240398328	System and a Method Thereof for Automatic Detection of Epileptogenic Focus in Pharmacoresistant Epilepsy	December 5, 2024
20240404711	IoT Based Dynamic Risk Assessment in Intelligent Building	December 5, 2024
20240350151	Sternal Bridge	October 24, 2024
US20240264666A1	Eye Sign Language Communication System	August 8, 2024
US20240335586A1	Electrospun Microfibrous Porous Stretchable Membranes and the Method of Preparation Thereof	October 10, 2024