# International Conference on Advancing Sustainable Development

- HYBRID -

# *Abstracts & Proceedings*

ORGANIZED BY

Manipal University College Malaysia (MUCM)

Melaka, Malaysia

Venue:

Academic Block (ACB1LT1), MUCM - Melaka Campus

**21 & 22 MAY 2026**

# Editors
# ICASD - 2026

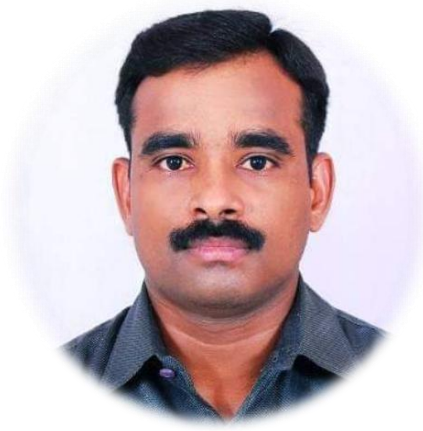
**Dr. Antony Vincent Samrot,** Associate Professor in Microbiology,

Director RMC, Manipal University College Malaysia, Melaka

**Dr. Vimalah Devi Gengathurai,** Senior Lecturer in Physiology,

Faculty of Medicine

Manipal University College Malaysia, Melaka



**Dr. Muthuvel Mani,** Senior Lecturer in Anatomy,

Faculty of Medicine

Manipal University College Malaysia, Melaka

**Dr. Sherly Deborah George,** Associate Professor in Physiology,

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**Mr. Baala Sharmma A/L K. Balasubramaniam,** Lecturer in Anatomy,

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# Organizing Committee
# ICASD - 2026

Convener: Dr. Antony Vincent Samrot

Organizing Chair: Mr. Baala Sharmma A/L K. Balasubramaniam

Organizing Chair: Dr. Arvind Chavhan

Organizing Secretary: Dr. Kalidasan Vasodavan

**Abstract book:**

- Dr. Vimalah Devi Gengathurai
- Dr. Muthuvel Mani
- Dr. Sherly Deborah George

**Registration:**

- Dr. Nur Izzati Ismail
- Dr. Mizanurfakhri Ghazali
- Ms. Khasmanizan Mohamad Yusoff

**Scientific:**

- Dr. Anita Devi Krishnan Thantry
- Dr. Mar Mar Lwin
- Dr. Khin Thein Oo
- Dr. Sanda Aung
- Dr. Su Sandar Ko Lay

**Event & food:**

- Dr. Jamal Moideen Muthu Mohamed
- Dr. Sugapriya Dhanasekaran
- Dr. Mehalene Jayaram
- Dr. Nur Ain Mohd Asri
- Dr. Seetha Munisamy

**Emcee:**

- Dr. Nurulmuna Mohd Ghozali
- Ms. Ng Choo Ting

**Safety & Emergency Response Team:**

- Mr. Puvanan Karunanithi
- Ms. Nur Hidayah Mohd Noor

# Message from Vice Chancellor, MUCM

# ICASD - 2026

It is my great pleasure to extend a warm welcome to all participants of the International Conference on Advancing Sustainable Development 2026 (ICASD 2026).

In an era where the challenges of sustainability demand urgent, collective, and innovative solutions, platforms such as ICASD play a vital role in fostering meaningful dialogue and interdisciplinary collaboration. This conference brings together scholars, researchers, and practitioners from diverse fields, united by a shared commitment to shaping a more sustainable and equitable future.

I commend the organizers for curating a program that not only highlights cutting-edge research but also encourages practical strategies and impactful partnerships. The exchange of knowledge and ideas at this conference will undoubtedly contribute to advancing sustainable development goals at both local and global levels.

I also extend my sincere appreciation to all presenters and participants for their valuable contributions. Your work reflects the spirit of inquiry, innovation, and responsibility that is essential in addressing the complex challenges facing our world today.

On behalf of Manipal University College Malaysia (MUCM), I wish you a productive and enriching conference experience.

Warm regards,

Prof. Dr. Jayakumar Gurusamy

Vice Chancellor, Manipal University College Malaysia (MUCM)

# Message from Pro Vice Chancellor, MUCM

# ICASD - 2026

It is a privilege to address the distinguished participants of the International Conference on Advancing Sustainable Development 2026 (ICASD 2026).

As we stand at the intersection of global challenges and transformative opportunities, the role of academia extends beyond knowledge creation to meaningful societal impact. Conferences such as ICASD 2026 exemplify this mission by creating a dynamic space where ideas are not only shared, but challenged, refined, and translated into actionable outcomes.

This gathering reflects the strength of collaborative thinking where diverse perspectives converge to address sustainability through innovation, research, and strategic partnerships. I am confident that the discussions and engagements throughout this conference will inspire new directions, strengthen networks, and catalyse solutions that are both practical and enduring.

I applaud the dedication of the organizing team and the commitment of all contributors whose efforts have made this conference possible. Your participation underscores a collective resolve to advance sustainable practices across disciplines and communities.

May this conference serve as a catalyst for continued dialogue, purposeful research, and impactful change.

Warm regards,

Prof. Dr. Adinegara Lutfi Abas

Pro Vice-Chancellor, Manipal University College Malaysia (MUCM)

# Message from President - DBSSB

# ICASD - 2026

On behalf of Digambarrao Bindu Smarak Samiti, Bhokar, Nanded, it is my distinct honor and privilege to welcome you to the International Conference on Advancing Sustainable Development (ICASD-2026). This prestigious gathering represents a significant milestone in our journey toward global academic collaboration and meaningful impact.

The conference theme, "Innovation, Intelligence, and Global Impact," resonates deeply with the core philosophy of our Samiti—to empower communities through education, research, and forward-thinking leadership. As we face increasingly complex environmental, social, and economic challenges, the fusion of cutting-edge technologies with data-driven intelligence offers our best path forward. This conference creates the ideal platform to explore how AI, smart systems, and scalable innovations can accelerate progress toward the United Nations Sustainable Development Goals (SDGs).

I extend my heartfelt gratitude to our dedicated organizing partners—Digambarrao Bindu College, Bhokar; Manipal University College, Malaka, Malaysia; and Acadivate—for their tireless efforts in bringing this vision to life. The hybrid format of ICASD-2026, hosted at Manipal University College, Malaka, Malaysia, Campus ensures inclusive participation from global scholars, practitioners, and policymakers, fostering cross-cultural dialogue and collaborative problem-solving.

Building upon the resounding successes of ICGASD-2024 in Thailand and ICASD-2025 in Dubai, this third in series promises to elevate the discourse on sustainable development to new heights. I encourage all participants—researchers, academicians, industry leaders, and students—to engage actively, share bold ideas, and forge partnerships that transcend borders.

Let us together harness the power of innovation and intelligence to create tangible, scalable solutions—not merely for academic discourse, but for the betterment of our planet and future generations.

Wishing you a productive and enriching conference.

With warm regards,

Dr. Madhav Rao Patil Kinhalkar

Ex Minister, Govt. of Maharashtra, India

President, Digambarrao Bindu Smarak Samiti Bhokar, Nanded, Maharashtra, India.

# Message from Principal - DBSSB
# ICASD - 2026

It gives me immense pleasure and pride to welcome you all to the International Conference on Advancing Sustainable Development (ICASD-2026) , organized jointly by Digambarrao Bindu College, Bhokar, Manipal University College, Malaka, Malaysia, and Acadivate. As the Principal of Digambarrao Bindu College, I am honored to see our institution play a pivotal role in this prestigious global event.

The chosen theme, "Innovation, Intelligence, and Global Impact," reflects the urgent need to align academic research with practical, technology-driven solutions for sustainable development. In an era where data is abundant and artificial intelligence is reshaping every sector; we must channel these tools toward achieving the United Nations Sustainable Development Goals (SDGs). This conference provides a remarkable platform for scholars, researchers, practitioners, and policymakers to come together, share groundbreaking ideas, and co-create scalable solutions that can transform societies.

Our college, established under the visionary ethos of Digambarrao Bindu Smarak Samiti, has always strived to foster quality education, research excellence, and community engagement. Hosting this third edition of the conference series—following the resounding successes in Thailand (2024) and Dubai (2025)—is a testament to our growing global reach and academic commitment. The hybrid format ensures that despite geographical distances, knowledge flows freely across borders, and collaboration becomes truly borderless.

I extend my sincere gratitude to our President, Digambarrao Bindu Smarak Samiti, for their unwavering support; to our international partners at Manipal University College, Malaka, for their seamless coordination; and to Acadivate for their expertise in making this conference a reality. I also thank our dedicated faculty, staff, and student volunteers who have worked tirelessly behind the scenes.

To all delegates, presenters, and attendees—I urge you to make the most of this opportunity. Engage, question, collaborate, and return inspired. The path to a sustainable future is paved with innovation and intelligence, and together, we can create lasting global impact.

Wishing you an intellectually enriching and memorable conference.

With warm regards,

Dr. Panjab Chavan

Principal Digambarrao Bindu College, Bhokar Dist. Nanded, Maharashtra, India.

# Message from President - SSES,A

# ICASD - 2026

Guided by the visionary philosophy of Dr. Panjabrao Deshmukh, founder member of Shri Shivaji Education Society, Amravati, that education must become an instrument for social transformation, empowerment of rural masses, scientific progress and welfare of humanity, Shivajians have continuously worked towards building an enlightened, inclusive and progressive society. Dr. Panjabrao Deshmukh firmly believed that knowledge and innovation should serve not merely individual advancement, but the larger cause of social responsibility, agricultural development, national progress and human welfare. His vision of combining modern scientific advancement with human values and social commitment continues to inspire generations of Shivajians in their academic and societal mission.

Technological advancement focused exclusively on human welfare, without adequate consideration for ecological balance and harmonious coexistence with nature, has significantly contributed to rising global concerns related to climate change, environmental degradation, depletion of natural resources, public health challenges and unsustainable patterns of economic growth. In the light of these realities, there is an urgent need for a thorough revision of human thought processes and developmental priorities to determine a rightful, balanced and sustainable direction for the future. The Indian philosophical principle of "Vasudhaiva Kutumbakam" — viewing the entire world as one family — offers a profound foundation for such a vision by emphasizing harmony, responsibility, coexistence and the preservation of the rights and well-being of every living being. It is this holistic and value-based approach that can truly guide humanity towards sustainable development.

Heartfelt acknowledgements to the researchers, academicians and scientific managers coming together with this vision. I extend my heartfelt best wishes to the organizers and all participants of the 3rd International Conference on Advancing Sustainable Development (ICASD–2026) for this remarkable international academic initiative.

I sincerely appreciate the visionary efforts of Acadivate Research and Innovation Foundation (ARIF) in creating global academic platforms that connect Indian higher educational institutions with internationally reputed universities such as Manipal University Malaysia. Such collaborations play a significant role in strengthening research culture, innovation, knowledge exchange and global academic networking.

I also take pride in the active participation of Shri Shivaji Education Society, Amravati, through Shri Shivaji Science College, Amravati, in this important international collaboration. Initiatives of this nature provide meaningful opportunities for faculty members, researchers and students to engage with the global academic community and contribute towards sustainable development through research and innovation.

I convey my best wishes for the grand success of the conference and for all future academic endeavors under this collaborative platform.

Harshawardhan P. Deshmukh., President,

Shri Shivaji Education Society, Amravati, (SSES,A) Maharashtra, India.

# Message from Principal - SSSC,A
# ICASD - 2026

Shri Shivaji Science College, Amravati constantly aspires to realize the dreams and educational vision of Shikshanmaharshi Krushiratna Dr. Panjabrao alias Bhausaheb Deshmukh through meaningful academic, scientific and socially relevant initiatives. This joint international academic venture is one such important step towards fulfilling that vision by promoting global knowledge exchange, research collaboration and sustainable development-oriented education.

In the present era of rapid scientific and technological advancement, humanity stands at a critical juncture where progress must be harmonized with environmental responsibility, ethical values and sustainable living. The increasing challenges of climate change, biodiversity loss, environmental degradation and uneven resource utilization remind us that development cannot remain confined only to economic growth and technological achievements. Sustainable development demands a broader vision that integrates scientific innovation with ecological sensitivity, social equity and global cooperation for the welfare of present and future generations.

The theme of the 3rd International Conference on Advancing Sustainable Development (ICASD–2026) is therefore highly relevant and intellectually significant in today's global context. It is encouraging to witness researchers, academicians, innovators, policymakers and scientific leaders coming together on a common platform to deliberate upon solutions for a more sustainable and responsible future.

I extend my heartfelt best wishes to the organizers and all participants of this remarkable international academic initiative. I sincerely appreciate the efforts of Acadivate Research and Innovation Foundation (ARIF) in creating global academic collaborations that connect Indian higher educational institutions with internationally reputed universities such as Manipal University Malaysia. Such initiatives play an important role in strengthening research culture, innovation, interdisciplinary thinking and international academic engagement.

It gives me immense pleasure that Shri Shivaji Science College, Amravati, under the aegis of Shri Shivaji Education Society, Amravati, is actively participating in this important international collaboration. These academic interactions provide valuable exposure to faculty members, researchers and students and inspire meaningful contributions towards sustainable development through research and innovation.

I convey my sincere best wishes for the grand success of the conference and for all future academic endeavors under this collaborative platform.

Dr. G. V. Korpe., Principal

Shri Shivaji Science College, Amravati (SSSC,A) Maharashtra, India.

# Message from Convener - MUCM
# ICASD - 2026

It is a distinct pleasure to welcome you to the International Conference on Advancing Sustainable Development (ICASD 2026). As we gather to share insights and innovations, we do so at a pivotal moment in global history where the intersection of research, technology, and sustainability has never been more critical.

The Research Management Centre (RMC) remains steadfast in its commitment to fostering an ecosystem where high-impact research transcends theoretical boundaries to provide tangible solutions for the planet. ICASD 2026 serves as a vital platform for this mission, bringing together a diverse cohort of academicians, researchers, and industry experts to deliberate on the multifaceted challenges of sustainable development. Each contribution represents a brick in the foundation of a more resilient and resource-efficient future.

I would like to extend my heartfelt congratulations to the organizing committee for their tireless efforts in bringing this forum to fruition. Most importantly, I thank the authors and presenters for their commitment to advancing knowledge that prioritizes the well-being of future generations.

It is my hope that the ideas shared within these pages spark new collaborations, inspire further inquiry, and lead to transformative actions that echo far beyond the walls of this conference.

I wish all participants an intellectually stimulating and productive experience.

Dr. Antony Vincent Samrot, Organizing Convener - ICASD 2026

Director, Research Management Centre

Associate Professor in Microbiology

Manipal University College Malaysia (MUCM)

# Message from Organizing Chair - MUCM
# ICASD - 2026

It is with immense pleasure and great pride that I welcome all delegates, speakers, researchers, academicians, healthcare professionals, and students to the International Conference on Advancing Sustainable Development (ICASD 2026).

ICASD 2026 stands as a platform dedicated to the pursuit of knowledge, innovation, collaboration, and meaningful scientific exchange. In a rapidly evolving world where healthcare, science, and education continuously intersect, conferences such as this play a vital role in shaping future directions, inspiring research, and strengthening interdisciplinary partnerships across institutions and nations.

This year's conference brings together a distinguished community of experts and emerging scholars who share a common passion for advancing science and improving human wellbeing. The collection of abstracts presented in this book reflects not only scientific excellence, but also the commitment, perseverance, and creativity of researchers working tirelessly to contribute meaningful solutions to present and future challenges.

As Organizing Chairperson, I firmly believe that knowledge grows stronger when shared. ICASD 2026 is more than just a scientific meeting; it is a space where ideas are transformed into collaborations, where curiosity sparks innovation, and where professional connections become lasting partnerships. Every presentation, discussion, and interaction during this conference carries the potential to inspire new perspectives and future breakthroughs.

I would also like to express my sincere appreciation to our keynote speakers, scientific committee members, reviewers, sponsors, collaborating institutions, and dedicated organizing teams whose continuous support and efforts have made this conference possible. Their commitment and hard work behind the scenes have ensured the successful realization of this international event.

As we gather with a shared vision for scientific advancement and educational excellence, I hope ICASD 2026 becomes a memorable and impactful experience for everyone involved. Let us continue to work together toward building a future driven by innovation, compassion, and collaborative progress.

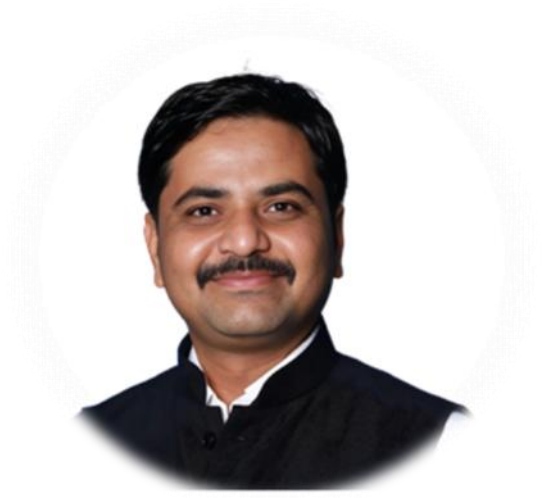
Thank you for your valuable participation, and I wish you a successful and inspiring conference experience.

Warm regards,

Mr. Baala Sharmma A/L K. Balasubramaniam, Organizing Chair - ICASD 2026

Lecturer in Anatomy, Faculty of Medicine - Melaka Campus, Manipal University College Malaysia, Melaka

# Message from Organizing Chair - DBSSB
# ICASD - 2026



It is my privilege and delight to welcome you to the International Conference on Advancing Sustainable Development (ICASD-2026) , a landmark event that brings together the brightest minds from across the globe to reimagine the future of sustainable development. As the Conference Chair, I am honored to witness the culmination of months of meticulous planning, collaboration, and shared passion for impactful research.

The theme of this year's conference, "Innovation, Intelligence, and Global Impact," is not merely a title, it is a call to action. In a world grappling with climate change, resource depletion, and social inequality, we must move beyond traditional approaches and embrace disruptive technologies, data-driven intelligence, and scalable innovations. This conference serves as a dynamic forum where academic rigor meets practical implementation, directly advancing the United Nations Sustainable Development Goals (SDGs).

Building on the outstanding legacy of ICGSD-2024 in Thailand and ICASD-2025 in Dubai, this third edition, hosted in a hybrid format at campus of Manipal University College, Malaka, in Malaysia promises to set new benchmarks for interdisciplinary dialogue and global cooperation. The partnership between Digambarrao Bindu College, Bhokar; Manipal University College, Malaka, Malaysia; and Acadivate Research and Innovation Foundation reflects our shared commitment to transcending geographical boundaries and fostering inclusive, cross-cultural knowledge exchange.

I extend my deepest gratitude to our esteemed Patrons for their visionary leadership and unwavering support: Hon'ble VC Prof. Dr. Jayakumar A/L Gurusamy, MUCM; Hon. Dr. Madhavrao Patil Kinhalkar, Ex-Minister, Govt. of Maharashtra and President of LDBS, Bhokar, India; Hon'ble Pro VC Prof. Adinegara Lutfi Abas, MUCM; Hon'ble Chief Operating Officer Mr. Gaurav Rekhi, Manipal International Campuses, Dubai & Malaysia; and Dr. Panjab Chavan, Principal of Digambarrao Bindu College, Bhokar, Nanded, MS, India. My sincere gratitude also goes to our dedicated Convenor, Associate Professor Dr. Antony Vincent Samrot, Director, RMC, MUCM, as well as to President Ms. Pallavi Rathod of Acadivate Research and Innovation Foundation for her exceptional leadership and collaboration.

I further thank our entire organizing committee, reviewers, volunteers, and technical staff who have worked tirelessly behind the scenes to ensure a seamless and enriching experience for all participants.

To our distinguished keynote speakers, plenary presenters, and contributing researchers—your work is the heartbeat of this conference. I encourage you to engage deeply, challenge assumptions, build networks, and most importantly, translate your insights into actionable solutions that will benefit communities and ecosystems worldwide.

I wish you all a productive, inspiring, and memorable ICASD-2026.

With sincere regards,

Dr. Arvind Chavhan, Organizing Chair - ICASD-2026

Head, Department of Zoology Coordinator, Internal Quality Assurance Cell (IQAC) Digambarrao Bindu College, Bhokar, Nanded, Maharashtra, India

# Program Schedule - 21st may 2026

# ICASD - 2026

| Time | Event | Venue |
|---|---|---|
| 8.30 am – 9.30 am | Registration | ACB-1-LT1 |
| 9.30 am – 10.30 am | Inauguration Ceremony | ACB-1-LT1 |

| 10.35 am – 12.55 pm | TECHNICAL SESSION 1 | ACB-1-LT1 |
|---|---|---|
| **Chairperson**: Assoc. Prof. Dr. Madhan Kumar Soutallu Janakiram<br>**Chairperson**: Assoc. Prof. Dr. Sambit Dash<br>**Moderator**: Ms. Nur Hidayah Mohd Noor | | |
| **10:35 am – 11:05 am** | **Keynote Lecture 1**<br>**Assoc. Prof. Dr. Antony Vincent Samrot**<br>Director, Research Management Centre, Manipal University College Malaysia<br>Artificial Dyes in Food and Their Impact – Transitioning to Biopigments for a Healthier Future | |
| **11.10 am – 11.20 am** | **OP-1: Phole Kamal Bhaurao**<br>Challenges & Opportunities for Women Entrepreneurship Development in Rural India with Global Perspective | |
| **11.20 am – 11.30 am** | **OP-2: Prasannarani Tanneru**<br>Lemna minor: A Sustainable High-Protein Feed Resource | |
| **11.30 am – 11.45 am** | **Tea Break** | **ACB-1-C5** |
| **11.45 am – 11.55 am** | **OP-3: Sunita Kanikaram**<br>High Fat Diet-Induced Metabolic Syndrome and its Modulation by Time-Restricted Feeding and Photobiomodulation in Experimental Male Wistar Rats | |
| **11.55 am – 12.05 pm** | **OP-4: Manjula Sree Veni**<br>The 2030 Climate Intelligence Roadmap: A Framework for Scaling Generative and Agentic AI to Accelerate SDG 13 Targets | |
| **12.05 pm – 12.15 pm** | **OP-5: Prasuna Kadudula**<br>Evaluation of Antivenom Activity of Methanolic Plant Extracts of Hemidesmus indicus (L.) R.Br. | |
| **12.15 pm – 12.25 pm** | **OP-6: Vikrant Deshmukh**<br>Occurrence of Microplastics in the Gastrointestinal Tract and Muscle of Bombay Duck (Harpadon nehereus): A Qualitative Study | |
| **12.25 pm – 12.35 pm** | **OP-7: Pravin Parimal**<br>Geomorphometric Characterization and Drainage Network Analysis of Bahiram Area, Amravati District, Maharashtra | |
| **12.35 pm – 12.45 pm** | **OP-8: Rekha Maggirwar**<br>Exploring Wild Edible Plant Diversity of Melghat for Sustainable Arbuscular Mycorrhizal Fungi (AMF) Integration | |
| **12.45 pm – 12.55 pm** | **OP-9: Mahesh Mudgal**<br>RNA: DNA Ratio as a Biomarker of Seasonal Growth in Labeo rohita | |
| **12.55 pm – 2.00 pm** | **Lunch** | **Sports Complex Foyer** |

# Program Schedule - 21st may 2026

# ICASD - 2026

| Time | Event | Venue |
|---|---|---|
| **2.00 pm – 2.55 pm** | **TECHNICAL SESSION 2** | **ACB-1-LT1** |
| **Chairperson**: Prof. Dr. Prakash Chandra Shetty<br>**Chairperson**: Assoc. Prof. Dr. Sherly Deborah George<br>**Moderator**: Ms. Nur Hidayah Mohd Noor | | |
| 2:00 pm – 2:30 pm | **Keynote Lecture 2**<br>**Assoc. Prof. Ts Dr. Yu Lih Jiun**<br>Head of Department, Mechanical Engineering, UCSI University<br>Eco-Friendly Limonene Coatings for Enhanced Mechanical and Antibacterial Rubber Performance | |
| 2.35 pm – 2.45 pm | **OP-10: Balu Pawar**<br>Micellar Media Assisted Advanced Guareschi–Thorpe Reaction for Synthesis of Anchored Pyridine Derivatives | |
| 2.45 pm – 2.55 pm | **OP-11: Umesh Kanerkar**<br>Some Less-Known Ethnomedicinal Plants Used in the Treatment of Spermatorrhoea | |
| **2.55 pm – 3.10 pm** | **Tea Break** | **ACB-1-C5** |
| **3.10 pm – 4.55 pm** | **ONLINE ORAL PRESENTATIONS** | **ACB-1-LT 1** |
| **Chairperson**: Prof. Dr. Prakash Chandra Shetty<br>**Chairperson**: Assoc. Prof. Dr. Sherly Deborah George<br>**Moderator**: Ms. Nur Hidayah Mohd Noor | | |
| 3.10 pm – 3.40 pm | **Keynote Lecture 3**<br>**Prof. Dr. Dinesh D. Khedkar**<br>Department of Botany, Shri Shivaji Science College<br>Biodiversity Informatics and Computational Intelligence for Sustainable Development Conservation and Ecosystem Resilience | |
| 3.45 pm – 3.55 pm | **OP (Online)-12: Lin Jun Cai**<br>Green Finance and Low-Carbon Economic Development: The Moderating Role of Climate Risk across 17 Selected Economies | |
| 3.55 pm – 4.05 pm | **OP (Online)-13: JinLing Li**<br>Carbon Emissions Trading and Stock Price Crash Risk: Evidence from Energy Companies Under the Low-Carbon Transition | |
| 4.05 pm – 4.15 pm | **OP (Online)-14: Madhumitha B. S.**<br>Ferrofluids as Theranostic Agents and Environmental Remediation | |
| 4.15 pm – 4.25 pm | **OP (Online)-15: R Deepthi**<br>Microbial Pigments: A Dual Role in Coloring and Sensing | |
| 4.25 pm – 4.35 pm | **OP (Online)-16: Jean Michelle Fernando**<br>Preparation and Characterization of Green-Synthesized Spions and Chitosan-Spions for Evaluation of Antibacterial and Dye Adsorption Performance | |
| 4.35 pm – 4.45 pm | **OP (Online)-17: Nanda Gopaalan**<br>Development and Characterization of Mycelium Mat for Eco-Friendly Applications | |
| 4.45 pm – 4.55 pm | **OP (Online)-18: Nishanth B.**<br>Therapeutic and Biotechnological Applications of Propolis | |
| **END OF FIRST DAY** | | |

# Program Schedule - 22nd may 2026
# ICASD - 2026

| Time | Event | Venue |
|---|---|---|
| 8.00 am – 9.00 am | Breakfast | ACB-1-C5 |

| 9.00 am – 10.30 am | TECHNICAL SESSION 3 | ACB-1-LT1 |
|---|---|---|
| **Chairperson**: Assoc. Prof. Dr. Mar Mar Lwin<br>**Chairperson**: Dr. Arvind Chavhan<br>**Moderator**: Mr. Puvanan Karunanithi | | |
| 9.00 am – 9.35 am | **Keynote Lecture 4**<br>**Prof. Ts Dr. Palsan Sannasi Abdullah**<br>Faculty of Agro-Based Industry, Universiti Malaysia Kelantan<br>Closing the Loop: Integrating Agrowaste System for Food, Energy, and Carbon Value | |
| 9.40 am- 9.50 am | **EP-1: Nur Hidayah Mohd Noor**<br>Enhancing Quality Learning in Tertiary Chemistry Education through Kahoot!: A Review | |
| 9.50 am – 10.00 am | **EP-2: Haridas Rathod**<br>A Geospatial Multi-Criteria Approach to Identifying Sustainable Development Zones in Marathwada | |
| 10.00 am – 10.10 am | **EP-3: Kavita Chandrakant Lawale**<br>The Intellectual Project of Haridas Narke: Disseminating Phule-Ambedkarite Thought in Contemporary India | |
| 10.10 am – 10.20 am | **EP-4: D.C. Pawar**<br>Green Chemistry: A Path to Sustainable Development - Principles, Methodologies, and Future Perspectives | |
| 10.20 am – 10.30 am | **EP-5: Vinay Teja**<br>Ascendancy of copper ions on optical bandgap, electronegativity, and ionic conductivity of $GeO_2$-$Li_2O$-$P_2O_5$-MgO glasses for photonic and optoelectronic applications | |
| **10.30 am - 10.45 am** | **Tea Break** | **ACB-1-C5** |

| 10.45 am - 12.20 pm | TECHNICAL SESSION 4 | ACB-1-LT1 |
|---|---|---|
| **Chairperson**: Prof. Dr. Jamal Moideen Muthu Mohamed<br>**Chairperson**: Prof. Dr. Sanda Aung<br>**Moderator**: Mr. Puvanan Karunanithi | | |
| 10.45 am – 11.20 am | **Keynote Lecture 5**<br>**Assoc. Prof. Dr. Chew Heng Hai**<br>Department of Physiotherapy, Faculty of Allied Health Profession, AIMST University<br>Fundamentals of Pelvic Floor Science from the Perspective of a Medical Professional: A Revisit | |
| 11.20 am – 11.30 am | **EP-6: Vimala Sakshi Gangu**<br>Research Scholar Revamping Rajkot: Where Industry Meets Climate and Mobility for a Brighter Tomorrow – Cross-Disciplinary Approaches for Global Impact | |
| 11.30 am – 11.40 am | **EP-7: Savita Bondhare**<br>Sentinels of Still Waters: The Role of Microinvertebrates in Maintaining Lentic Ecosystem Sustainability | |
| 11.40 am – 11.50 am | **EP-8: Keshav Patil**<br>Cultivating a Sustainable India Through Marathi Literature: An Ecocritical Study of Environmental Consciousness in Traditional and Modern Writings | |

# Program Schedule - 22nd may 2026

# ICASD - 2026

| Time | Event | Venue |
|---|---|---|
| **10.45 am - 12.20 pm** | **TECHNICAL SESSION 4 (CONT ..)** | **ACB-1-LT1** |
| 11.50 am – 12.00 pm | **EP-9: Rohini Patel**<br>Sustainable Aviation Fuel | |
| 12.00 pm – 12.10 pm | **EP-10: Dilip Maske**<br>The Social Anatomy of Climate-Induced Distress Migration: A Comparative Study of Livelihood Adaptation and its Impact on Social Cohesion in Marathwada's Villages | |
| 12.10 pm – 12.20 pm | **EP-11: Sushilkumar Chaudhari**<br>The Study of Genetic Diversity of Honeybee Apis Florea Species in Southern, Western and Northern Part of Maharashtra, India | |
| **11.20 am – 12.20 pm** | **ONLINE POSTER PRESENTATION** | **ACB-1-C6** |
| **Chairperson**: Prof. Dr. Sugapriya Dhanasekaran<br>**Chairperson**: Assoc. Prof. Dr. Remya Vallathol<br>**Moderator**: Dr. Nur Izzati Ismail | | |
| 11.20 am – 11.30 am | **EP (Online)-12: Sumeet Dhondge**<br>Ecosystem Services and Economic Significance of Ant Fauna in Painganga Wildlife Sanctuary: A Baseline Assessment for Sustainable Conservation | |
| 11.30 am – 11.40 am | **EP (Online)-13: Anuja Kamble**<br>Bioefficacy of Plant-Based Extracts for the Management of Rhyzopertha dominica (Fabricius) in Stored Grains | |
| 11.40 am – 11.50 am | **EP (Online)-14: Vijendra Jadhav**<br>The Evolutionary Ecology of Macroinvertebrates: Advancing Sustainability and Ecosystem Restoration Through Biomonitoring | |
| 11.50 am – 12.00 pm | **EP (Online)-15: Pooja Ade**<br>Bridging Ecology and Economy: A Strategy for Ecosystem Restoration through Apiculture in Atmanirbhar Bharat for the Economic Enhancement of Tribes in Marathwada, India | |
| 12.00 pm – 12.10 pm | **EP (Online)-16: Harshaa Rajabalakumar**<br>Advancements in Sustainable Biocomposites: Utilizing Engineered Biopolymers from Waste Streams for Multi-Functional Products | |
| 12.10 pm – 12.20 pm | **EP (Online)-17: Sarah M S**<br>Valorisation of Corn Husk for Development of Biomaterials | |
| **12.20 pm - 2.30 pm** | **Lunch** | **Sports Complex Foyer** |

| | | |
|---|---|---|
| **2.30 pm - 3.35 pm** | **KEYNOTES** | **ACB-1-LT1** |
| **Chairperson**: Prof. Dr. Rekha Prabhu<br>**Chairperson**: Dr. Dinesh Dayaram Khedkar<br>**Moderator**: Mr. Puvanan Karunanithi | | |
| 2.30 pm – 3.05 pm | **Keynote Lecture 6**<br>**Mr. Kasirajan Kasipandian**<br>Faculty of Engineering, Built Environment and IT, MAHSA University<br>Beyond Energy: Building a Sustainable World Through Innovation | |
| 3.05 pm – 3.35 pm | **Keynote Lecture 7**<br>**Senior Assoc. Prof. Dr. Subramani Parasuraman**<br>Unit Head, Pharmacology Unit, Faculty of Pharmacy, AIMST University<br>Alternatives to Animal Testing and the Future of Preclinical Research | |
| 3.35 pm – 4.30 pm | Valedictory Ceremony | ACB-1-LT1 |
| **4.30 pm – 4.45 pm** | **Tea Break** | **ACB-1-C5** |
| **END OF CONFERENCE** | | |

# Abstract - Keynote-01
# ICASD - 2026

## Artificial Dyes in Food and Their Impact – Transitioning to Biopigments for a Healthier Future

Dr. Antony V Samrot, Director, Research Management Centre
Manipal University College Malaysia, Melaka, Malaysia

**ABSTRACT**:

The modern food industry relies heavily on synthetic colorants to enhance visual appeal and product consistency, yet growing toxicological evidence has raised concerns about their potential links to hypersensitivity, oxidative stress, and behavioral changes in children. This keynote highlights the biochemical and physiological impacts of widely used artificial dyes while addressing the global shift toward clean-label products and stricter regulatory oversight. In response, it underscores the promising role of natural biopigments derived from plants, microbes, and fungi, including anthocyanins, carotenoids, and betalains. These compounds not only provide vibrant coloration but also offer functional health benefits such as antioxidant, anti-inflammatory, and antimicrobial properties. Advances in extraction, stabilization, and biotechnological production further support their large-scale application, positioning biopigments as sustainable, health-promoting alternatives that can drive the transition toward a safer and more future-ready food system.

Keywords: Artificial Food Dyes, Biopigments, Food Safety, Functional Foods, Sustainable Biotechnology, Clean Label.

# Abstract - Keynote-02
# ICASD - 2026

## Eco-Friendly Limonene Coatings for Enhanced Mechanical and Antibacterial Rubber Performance

Dr. Yu Lih Jiun, Associate Professor, UCSI University

**ABSTRACT:**

This keynote presents a green coating strategy to enhance the performance and sustainability of natural rubber (NR) films using D-limonene, a renewable bio-based essential oil. By applying controlled immersion techniques and varying limonene concentrations, the study shows significant improvements in tensile strength, elasticity, and antibacterial activity, with 40 wt% identified as the optimal formulation. The approach replaces conventional petroleum-based coatings with a biodegradable alternative, reducing chemical toxicity and environmental impact while improving material efficiency. The resulting antimicrobial rubber films are well-suited for healthcare and industrial applications, offering safer and more durable solutions. This work supports sustainable development by aligning with SDG 3 (Good Health and Well-being), SDG 9 (Industry, Innovation and Infrastructure), and SDG 12 (Responsible Consumption and Production), demonstrating how green materials engineering can advance both performance and environmental responsibility.

# Abstract - Keynote-03
# ICASD - 2026

## Biodiversity Informatics and Computational Intelligence for Sustainable Development Conservation and Ecosystem Resilience

*Dr. Dinesh D. Khedkar, Professor, Department of Botany, Shri Shivaji Science College, Amravati*

**ABSTRACT:**

Biodiversity forms the foundation of ecological stability, sustainable development, climate resilience, food security, and future bioeconomy innovations. However, increasing habitat degradation, climate change, anthropogenic pressures, and fragmentation of biological information have created an urgent need for integrated computational systems capable of transforming biodiversity data into actionable ecological intelligence. Biodiversity Informatics has therefore emerged as an interdisciplinary domain integrating taxonomy, molecular biology, ecological sciences, geospatial analytics, artificial intelligence, and computational biology for systematic documentation, analysis, conservation, and sustainable utilization of biological resources.

Modern biodiversity informatics frameworks facilitate the development of interconnected biological information networks integrating plant taxonomy, diagnostic morphological characters, molecular signatures, phytochemical and genetic profiling, phenological observations, geographical distribution, ecological parameters, and associated ecosystem interactions into structured computational platforms. Such integrated systems enable evidence-based biodiversity assessment, ecological modelling, species distribution prediction, conservation prioritization, and biodiversity value discovery. Computational integration of ecological interactions including plant–pollinator relationships, trophic associations, climate-linked habitat responses, species coexistence patterns, and ecosystem resilience indicators provides new opportunities for understanding ecosystem dynamics under changing environmental conditions.

Advances in geospatial informatics, machine learning, high-performance computing, DNA-based characterization, and ecological modelling have significantly enhanced the capacity for large-scale biodiversity analysis and predictive conservation planning. FAIR biodiversity data principles, interoperable repositories, digital biodiversity networks, and computational intelligence platforms are increasingly becoming central components of biodiversity governance and sustainable development frameworks worldwide.

The Melghat Plant Databank (MPDB) developed at Shri Shivaji Science College, Amravati represents an emerging regional biodiversity informatics initiative integrating taxonomic, medicinal, ecological, and geographical information of the Melghat region into a structured digital platform. The database is continuously expanding through systematic biodiversity documentation, metadata integration, and computational organization of regional floristic resources.

MPDB is progressively evolving into a comprehensive biodiversity intelligence tool for academicians, researchers, forest departments, administrators, policy makers, students, and conservation stakeholders by supporting biodiversity analysis, ecological understanding, sustainable utilization, and evidence-based conservation planning.

Keywords: Biodiversity Informatics, Ecological Networks, Species Distribution Modeling, Geographic Information Systems, Molecular Taxonomy, Conservation Biology, Bioinformatics, Ecosystem Analysis

# Abstract - Keynote-04
# ICASD - 2026

## Closing the Loop: Integrating Agrowaste Systems for Food, Energy, and Carbon Value

Ts. Dr. Palsan Sannasi Abdullah, Associate Professor
Agro Product Technology Program, Faculty of Agro-Based Industry, Universiti Malaysia Kelantan (UMK)
Jeli Campus, 17600 Jeli, Kelantan, MALAYSIA.

**ABSTRACT:**

Large volumes of agricultural residues are produced each year, yet much of this material remains underutilized or poorly managed, leading to environmental concerns and missed value opportunities. This sharing explores how these residues can be redirected into integrated systems that supports food production, energy needs, and carbon outcomes. The approach focuses on converting agro waste into useful products, including biochar, compost, as soil amendments, biomass fuels, among others. When combined with biochar, composting and co-composting improve nutrient retention, enhance soil structure, and increase the efficiency of organic inputs. Biomass-based fuels provide an alternative practical energy option, while biochar contributes to long-term carbon storage in soils, creating pathways for participation in emerging carbon value systems. Emphasis is placed on community-scale implementation using simple technologies and locally available resources. By linking agro waste processing with agricultural application, communities can reduce input costs, improve productivity, and generate additional value streams. These actions align with Sustainable Development Goals and circular economy principles. Overall, the sharing highlights how a more integrated handling of agro resources, through biochar production, composting, and co-composting can strengthen agricultural resilience while generating environmental and socio- economic value.

# Abstract - Keynote-05
# ICASD - 2026

## Fundamentals of Pelvic Floor Science from the Perspective of a Medical Professional: A Revisit

Dr. Chew Heng Hai, Associate Professor
Department of Physiotherapy, Faculty of Allied Health Profession, AIMST University

**ABSTRACT:**

The pelvic floor remains a complex and somewhat unclear area within medical science, representing a shared yet often contested domain among anatomists, urogynecologists, and coloproctologists. These specialists frequently differ not only in their approaches to related diseases but also in their fundamental understanding of pelvic floor anatomy. Conditions affecting this region tend to have poorer prognoses and higher complication rates compared to other body areas, indicating significant opportunities for advancement in pelvic floor medicine.

Several contentious issues persist: the routine use of episiotomy is still debated; scientific support for immediate postpartum pelvic floor exercises is limited; recurrent hemorrhoids often recur despite advanced surgical techniques; and internal sphincterotomy, the gold standard treatment for chronic anal fissure, carries a growing risk of permanent incontinence. Additionally, pelvic sling and mesh surgeries have been linked to some of the most serious surgical complications in medical history. These challenges are not attributable to any single hospital, surgeon, or product.

Recognizing these complexities, at least one UK expert has called for a reassessment of pelvic floor science. While multidisciplinary management of pelvic floor diseases is appropriate, it is illogical for experts to hold divergent interpretations of the basic anatomical science of the same region. The goal of this conference's academic exchange is to unite all specialists involved with the pelvic floor to foster collaborative research aimed at uncovering the truth and achieving consensus on the fundamental science. This shared understanding is essential to advancing medical care and improving patient outcomes in this challenging field.

Keywords: Pelvic floor, Urogynecologists, Coloproctologists, episiotomy, haemorrhoid, chronic anal fissure, incontinence, sling & mesh surgery, mesh complication.

# Abstract - Keynote-06
# ICASD - 2026

## Beyond Energy: Building a Sustainable World Through Innovation

Mr. Kasirajan Kasipandian
Senior Lecturer and Manager for Research, Communication Outreach Officer, MAHSA University

**ABSTRACT:**

The primary goal of this conference is to promote advanced sustainable development in Malaysia while aligning with the United Nations Sustainable Development Goals (SDGs) for the betterment of the global community. However, these goals can only be achieved through meaningful action and active participation from the public. This talk will focus on practical and innovative sustainable development projects that can create real impact in our cities, communities, and countries. Special emphasis will be given to Solar power generation projects and modern solar technologies, Floating solar panel systems and their future potential, Various renewable energy resources and their applications, Smart sustainable solutions for urban and rural development, Green technology innovations for future generations, Community-driven sustainability initiatives and energy awareness. The session is designed to be interactive, insightful, and future-oriented, allowing participants to explore emerging technologies and discover how sustainable practices can be implemented effectively in daily life. Participants will gain new ideas, practical knowledge, and inspiration to contribute toward building a cleaner, greener, and more energy-efficient world. Together, through innovation, awareness, and collective action, we can accelerate the achievement of the Sustainable Development Goals and move closer to creating a sustainable world by 2030 in a faster, smarter, and more effective manner.

# Abstract - Keynote-07
# ICASD - 2026

## Alternatives to Animal Testing and the Future of Preclinical Research

Dr. Subramani Parasuraman
Unit of Pharmacology, Toxicology and Basic Health Sciences
Faculty of Pharmacy, AIMST University, Malaysia.

**ABSTRACT:**

Animal models have been used in preclinical research for the last 150 years in pharmacological and toxicological research. Preclinical models were extensively employed in the drug development process in the middle of the twentieth century to confirm the efficacy and safety of medications. According to the literature, over 20 million animal subjects are used annually in biomedical research, primarily in mouse and rat models. However, their translation to humans has raised questions about clinical validity, usefulness, and ethical issues, prompting the scientific community to reconsider the use of animals. In January 2023, changes to the Federal Food, Drug, and Cosmetic Act of 1938 were implemented following the passage of the FDA Modernization Act 2.0, which allows alternatives to animal testing and no longer requires animal studies before human clinical trials. It is critical to establish the safety of any investigational drug before proceeding to human clinical trials. According to the World Medical Association (WMA) Declaration of Helsinki, clinical trials must be carried out using a comprehensive understanding of the scientific literature, including sufficient evidence from animal and laboratory experiments. However, alternative methods may also be used to ensure the safety of medications. This chapter summarizes the current state of animal use in research, as well as alternatives and future directions regarding the use of animal models in research.

# Abstract - OP-01
# ICASD - 2026

## Challenges & Opportunities for Women Entrepreneurship Development in Rural India with Global Perspective

Dr. Phole Kamal Bhaurao*

*Assistant Professor & Head Department of Commerce, Digambarrao Bindu ACS College Bhokar District, Nanded MS, India*

**ABSTRACT:**

Rural women are increasingly running their own businesses, but their socio-economic contributions and entrepreneurial potential remain largely unrecognized and underutilized. They focus on small-scale, informal activities with low productivity and low profits. Rural women's entrepreneurship can contribute to economic growth in developing countries and clearly represents untapped potential. Women entrepreneurship in India is evolving rapidly, driven by digital adoption, government support, and increasing education, despite deep-seated patriarchal barriers, financial constraints, and work-life imbalance. While challenges include limited capital, mentorship, and societal bias, global opportunities are expanding through e-commerce, international trade, and enhanced networking, offering potential to transform the economic landscape. Rural women entrepreneurs in India face significant barriers, including limited access to finance, low education, patriarchal social structures, and poor infrastructure, which stifle growth and innovation. However, opportunities are emerging through SHGs, digital technology, government support (SIDBI/NABARD), and market expansion for local crafts. Global perspectives emphasize leveraging technology and skill development to bridge the gender gap. Therefore, it is essential to eliminate employment discrimination and create new opportunities in traditional, non-traditional and highly productive areas. The Government will have to play an active leading role for promoting programme relating to women empowerment and encouragement.

Keywords: *Women Employment, Rural Entrepreneurship, Economic Growth, Challenges, Opportunities, Government Schemes, Facilities, Future Programme, Global Perspectives*.

# Abstract – OP-02
# ICASD - 2026

## Lemna minor: A Sustainable High-Protein Feed Resource

Prasannarani Tanneru*

*Department of Botany, Lal Bahadur Shastri Mahavidyalaya, Dharmabad*

**ABSTRACT:**

Lemna minor, a small floating aquatic angiosperm, is widely distributed and commonly forms dense mats on nutrient-rich freshwater bodies. It thrives in both tropical and temperate regions, making it a readily available biomass resource. One of the major constraints in aquaculture and livestock production is the high cost and limited availability of protein-rich feed with high biological value. This study investigates the biochemical composition of Lemna minor, including protein, carbohydrate, lipid content, and percentage dry weight. The results reveal that Lemna minor contains significantly higher protein levels compared to conventional feed sources. Additionally, its nutritional composition is influenced by water chemistry, particularly nitrogen concentration, which plays a crucial role in protein accumulation. The findings highlight the potential of Lemna minor as a cost-effective, sustainable, and environmentally friendly alternative protein source for fish, poultry, and indigenous livestock. Its large-scale utilization could help reduce feed costs and support sustainable aquaculture and animal production systems.

Keywords: *Lemna minor, Protein, Nutrition, aquaculture, biological value.*

# Abstract - OP-03
# ICASD - 2026

## High Fat Diet -induced metabolic syndrome and its modulation by Time-Restricted Feeding and Photobiomodulation in experimental male Wistar Rats

Sunita Kanikaram[1] *, Venkata Murali Nadiminti[1], Sriteja Ganta[1], Sudheendra Babu Mathangi[1], Bhanu Prasad Gadde[2]

*[1]Department of Zoology and Aquaculture, Acharya Nagarjuna University, Nagarjuna Nagar 522510, Guntur, Andhra Pradesh, India*
*[2]Long Beach Chemists, Long Beach 11561, New York, USA*

**ABSTRACT:**

Metabolic syndrome is characterized by the presence of at least three metabolic abnormalities, including central obesity, high blood glucose and dyslipidemia. The coexistence of these conditions increases the risk of cardiovascular disease and diabetes. The aim of this study is to determine the effects of high saturated fat from coconut oil on metabolic health of Wistar rats. Male Wistar rats were used for this study. Rats were randomized into five groups, assigned for two different types of diet (Standard rat pellet and high-fat diet). Group-1 considered as control diet group, Group-2 to Group-5 were fed with a high-fat diet (HFD). Within the HFD groups, Group-4 underwent time restricted feeding (TRF) and Group-5 received Photobiomodulation therapy (PBMT). Anthropometric, hematological and biochemical parameters were measured and histopathology of the adipose tissue studied using standard procedures. The levels of biochemical and hematology parameters of HFD and Long-term – HFD (L-HFD) groups were significantly elevated while compared to the control and treated groups. All the treated groups showed significant reduction in fasting glucose compared to control groups. TRF and PBMT groups showed significantly lower value of fasting glucose compared with HFD groups. Total protein, albumin and globulin levels were significantly higher in all treated groups. Histological evaluation revealed inflammatory crown like structures and early fibrosis, hypertrophy and lipid accumulation in the adipose tissue of HFD and L-HFD groups, and smaller adipocytes with improved tissue structure observed in TRF and PBMT treated groups.

Keywords: *Metabolic syndrome, High-fat diet, Time restricted feeding, Photobiomodulation therapy, Hypertrophy.*

# Abstract - OP-04
# ICASD - 2026

## The 2030 Climate Intelligence Roadmap: A Framework for Scaling Generative and Agentic AI to Accelerate SDG 13 Targets

S. Manjula Sree Veni*

*Department of Zoology, Maris Stella College, Vijayawada, Andhra Pradesh, India*

**ABSTRACT:**

Sustainable Development Goal 13 (SDG 13) is the world's climate Emergency Plan. Its goal is to stop the damage and to get ready for a changing world. The UN has set focus on getting ready for disasters, changing laws, and finding the money to pay for it all. The present climate problem is record-breaking heat and a gap between climate targets and actual emissions reductions. SDG 13, helps by coordinating global efforts to reduce greenhouse gas emissions, protect life from climate related disasters, and finance the transition to a green economy. In the context of the 2030 climate Roadmap, the shift is moving from traditional habits to new smart actions. Generative AI provides the goal, and Agentic AI works independently to achieve it. These two technologies work together to hit 2030 targets. We have the tools, but we don't have enough people to run them globally. Responsible AI 2.0, edge-driven decentralized models and small Language Models (SLMs) like ChatGPT require less electricity and computer power, and are Efficient, Accessible and more Specific. The plan is to move away from "big and wasteful" AI to "small, smart, and safe" AI that works everywhere. These systems work instantly and without human breaks, and to cut global emissions by 45% almost half of the total goal by 2030. Environmental, Social and Governance impact (ESG reporting) reduces manual efforts by 30-90% saving where the computer is faster and more accurate at finding numbers than a person. These systems help us from looking at data to solving the problem automatically. In this Paper, the data will provide an action plan for governments and industries to transform climate data into action, ensuring to achieve our climate goals.

Key words: *Climate Intelligence, SDG 13, Generative AI, Agentic AI, ESG reporting*

# Abstract - OP-05
# ICASD - 2026

## Evaluation of Antivenom activity of methanolic plant extracts of Hemidesmus indicus (L.) R.Br.

Prasuna Kadudulal*

**Department of Zoology, Kakatiya University, Vidyaranyapuri - 506 009, Warangal, Telangana State, India*

**ABSTRACT:**

Hemidesmus indicus (L) R.Br. recommended by the Ministry of Health is a traditional Ayurvedic medicinal plant is selected to investigate the antivenom properties. The inhibitory activities of root and leaf extracts against cobra venom is done by pharmacological analysis in vitro done by neutralisation of fibrogenolytic activity, procoagulant activity and haemolytic activity. The leaf crude methanolic extract showed promising inhibition activity against protease, phospholipase A2 and hyaluronidase enzymes whereas the phosphodiesterase and phosphomonoesrerase could not be inhibited. H. indicus proves its ethnobotanical usage against cobra venom by inhibiting their toxic proteins through elaborated different in vitro analysis and should be further confirmed by in vivo studies using animal models. This work shows that H. indicus extracts could lead to the development of new drugs against the venom of Indian snakes.

Keywords: *Antivenom activity, Hemidesmus indicus, Protease, Phospholipase A2, Hyaluronidase, Phosphodiesterase, Phosphomonoesterase*

# Abstract - OP-06
# ICASD - 2026

## Occurrence of Microplastics in the Gastrointestinal Tract and Muscle of Bombay Duck (Harpadon nehereus): A Qualitative Study

Ram Salvi, Niru Rajput, Aisha Zaid, Vikrant Deshmukh*

*K. J. Somaiya College of Science and Commerce, Vidyavihar, Mumbai, 77.*

**ABSTRACT:**

Microplastics (MPs) pollution is emerging as a rapidly growing environmental problem, causing a paramount threat to marine ecosystems. Marine organisms form an essential component of the human food supply, hence create a potential pathway for microplastics to enter the human body. Adverse health effects may arise due to the accumulation of microplastics in biological tissues, highlighting the need of identification and assess sources of its exposure through diet. The present study was conducted in two stages. In the first stage, commonly consumed fish species were screened through a field survey to identify popular market varieties. In the second stage, samples of Bombay Duck (Harpadon nehereus) were collected from local fish markets at three locations in Mumbai and examined for the presence and morphological characteristics of microplastics in the gastrointestinal tract (GIT) and muscle tissue (flesh). The samples were subjected to Potassium Hydroxide (KOH) digestion followed by density separation by Zinc Chloride. The analysis revealed the presence of microplastics in four distinct colour types transparent, red, blue and black, it indicates that multiple potential sources of contamination in the seawater from the region fishes were captured. This short communication reveals preliminary qualitative evidence of microplastic occurrence in both the digestive tract and edible tissues of H. nehereus. Future studies will focus on quantitative estimation and detailed physicochemical characterisation of the detected microplastics.

Keywords: *Microplastics, GIT, Flesh, Herpadon nehereus, Qualitative analysis*

# Abstract - OP-07
# ICASD - 2026

## Geomorphometric Characterization and Drainage Network Analysis of Bahiram Area, Amravati District, Maharashtra

Pravin S. Parimal*, Akshay D. Ghatol

*Department of Geology, G. S. Tompe Arts, Commerce & Science College, Chandur Bazar, District Amravati - 444702*

**ABSTRACT**:

This study provides a comprehensive quantitative morphometric evaluation of the Bahiram area, located in the northern part of the Amravati district, Maharashtra. Utilizing advanced Remote Sensing and GIS technologies, the research assesses the geo-hydrological characteristics of the watershed by analyzing linear, aerial, and relief aspects. The drainage network is identified as a fifth-order system exhibiting a sub-dendritic to dendritic pattern. The analysis reveals a drainage density of 2.69 km/km², indicating a fine drainage texture and high runoff potential. An Elongation Ratio showing 1 suggests a circular basin configuration, facilitating efficient runoff discharge, while a Circularity Ratio showing 0.26 reflects a moderate to low relief. These findings offer critical insights into the basin's hydrological behavior, providing a foundational tool for local farmers and policymakers to implement effective soil and water conservation strategies in the Bahiram region.

Keyword: *Morphometric analysis, Remote sensing, GIS, Bahiram Area, District Amravati, Maharashtra*

# Abstract - OP-08
# ICASD - 2026

## Exploring Wild Edible Plant Diversity of Melghat for Sustainable Arbuscular Mycorrhizal Fungi (AMF) Integration

Darwhekar N. T., Maggirwar R. C*.

*Department of Botany, Shri Shivaji Science College, Amravati, Maharashtra, India*

**ABSTRACT:**

The present study documents and evaluates the diversity and traditional utilization of wild edible plants used by indigenous communities of the Melghat region in Maharashtra, India. Located within the Satpura hill range, Melghat represents a biodiversity-rich landscape that supports a wide variety of wild plant species contributing significantly to local food security and nutrition. Ethnobotanical field surveys were conducted across six villages and adjoining farmlands using structured interviews and participatory observation methods. The study involved indigenous tribal communities, primarily Korku and Gond to document traditional knowledge associated with wild edible plants. A total of 42 wild edible plant species were recorded, including leafy vegetables, fruits, tubers and seeds belonging to diverse plant families. Commonly utilized species identified during the survey include Celosia argentea L., Chenopodium album L., Bidens pilosa L. and Phyllanthus amarus L. Detailed information on local names, edible parts, seasonal availability, preparation methods and modes of consumption was systematically compiled. The findings reveal that wild edible plants serve as vital sources of micronutrients, dietary fibre and medicinal compounds, particularly during periods of food scarcity. However, the study also indicates a gradual decline in traditional ecological knowledge among younger generations due to modernization, habitat degradation and changing dietary patterns. The research underscores the importance of conserving wild edible plant diversity and preserving indigenous knowledge systems for sustainable resource utilization and biodiversity management. It further highlights the need for nutritional assessment, value addition and community-based awareness programs to promote the integration of wild vegetables into contemporary diets and livelihood strategies. In future the mycorrhizal fungal association with these wild edible plants will be studied and pot experiment will be performed to find effect of most dominant AMF species on frequently observed wild edible plant species. These insights contribute to broader discussions on food security, ethnobotany and sustainable development.

Keywords: *Melghat forest, Wild edible plants, AMF, Nutritional security, Ethnobotany, Sustainable utilization*.

# Abstract - OP-09
# ICASD - 2026

## RNA: DNA Ratio as a Biomarker of Seasonal Growth in Labeo rohita

Mudgal*[1] M. B., Ghanbahadur[2] A.G., Mudbe[1] P. K.

*Department of Zoology GES's HPT Arts & RYK Science College, Nashik.*

**ABSTRACT:**

The present study was carried out to evaluate seasonal variation in RNA:DNA ratio of Labeo rohita. Different tissues such as liver, intestine, muscle, gill, testis and ovary were analysed during summer, winter, monsoon, pre-breeding and post-breeding seasons. The RNA:DNA ratio showed clear seasonal variation in all tissues (Table 1-6). Higher values were observed during summer, monsoon and pre-breeding seasons, while lower values were recorded during winter. Liver tissue showed maximum variation with values ranging from 2.6 to 4.4, while muscle showed comparatively lower variation. Zooplankton biomass also showed seasonal variation (Table 7), with higher values during pre-breeding and summer seasons. A positive relationship was observed between RNA:DNA ratio and zooplankton availability. Present study indicates that RNA:DNA ratio can be used as a reliable biochemical indicator of growth, metabolic activity and nutritional condition in Labeo rohita. Similar observations have been reported in earlier studies on freshwater fishes (Bulow, 1970; Buckley et al., 1984).

Keywords: *Labeo rohita, RNA:DNA ratio, seasonal variation, biomarker, nutritional status*

# Abstract - OP-10
# ICASD - 2026

## Micellar Media Assisted Advanced Guareschi-Thorpe reaction for Synthesis of Anchored Pyridine Derivatives.

Dr. Balu V. Pawar*

*Assistant Professor, Department of Chemistry Gokhale Education Society*
*HPT Arts and RYK Science College Nashik, Maharashtra-422005.*

**ABSTRACT:**

Micellar media assisted synthesis of different Hydroxy-cyanopyridines are easily carried out via an advanced version of the Guareschi–Thorpe reaction. A three-component condensation of alkyl cyanoacetate or cyanoacetamide with 1,3-dicarbonyls and ammonium carbonate in an aqueous TX-100 micellar medium was investigated. Reactions proceed productively in short reactime time to give the desired products in 5-92% yields. This new multi-component approach for hydroxy-cyanopyridine synthesis is environmentally benign, inexpensive, user-friendly and simple work-up are extra advantages.

# Abstract - OP-11
# ICASD - 2026

## Some Less-Known Ethnomedicinal Plants Used in the Treatment of Spermatorrhoea

Umesh R. Kanerkar*[1], Sanjay V. Satpute[2] and Prabha Y. Bhogaonkar[3]

*[1]Department of Botany, G. S. Tompe Arts, Commerce and Science College, Chandur Bazar*
*[2]Department of Botany, Mahatma Fule Mahavidyalaya, Warud*
*[3]Department of Botany, Govt. Vidarbha Institute of Science and Humanities, Maharashtra, India*

**ABSTRACT:**

Ethnobotany exhibits the complex relationship between human culture and the use of plants with particular emphasis on traditional and tribal communities. In recent years, the field has experienced a significant revival driven by the growing need to document indigenous knowledge of plant utilization and its vital role in biodiversity conservation.

Spermatorrhoea, a condition characterized by involuntary seminal discharge is a significant yet often underreported male reproductive health concern. Traditional medicinal systems have long utilized plant-based remedies to manage such disorders offering a holistic and accessible approach for treatment. The present study aims to document and analyze some lesser-known ethnomedicinal plants used in the treatment of spermatorrhoea, with special reference to indigenous knowledge systems. Field surveys were conducted in selected regions and data was collected through interviews with traditional healers, herbal practitioners and local inhabitants. The study highlights several plant species along with their botanical identity, parts used, preparation methods and mode of administration. These plants are traditionally believed to possess aphrodisiac, nervine booster and reproductive health-enhancing properties. The findings emphasize the importance of preserving such valuable traditional knowledge which is gradually declining due to modernization and lack of documentation. Furthermore, the documented plants may serve as potential candidates for phytochemical and pharmacological investigations contributing to the development of effective herbal drugs. The study underscores the need for scientific validation of these remedies to integrate them into modern healthcare systems.

Keywords: *Ethnomedicinal, Spermatorrhoea, Traditional Knowledge, Reproductive Health*

# Abstract - OP (online)-12
# ICASD - 2026

## Green Finance and Low-Carbon Economic Development: The Moderating Role of Climate Risk across 17 Selected Economies

LinJun Cai*[1], Wee-Yeap Lau[2], Kok-Haur Ng[3],

[1]*Institute for Advanced Studies, Universiti Malaya, Malaysia.*
[2] *Faculty of Business and Economics, Universiti Malaya, Malaysia.*
[3] *Institute of Mathematical Sciences, Faculty of Science, Universiti Malaya,*

**ABSTRACT:**

As the global community endeavors to combat climate change, the interplay between green finance and climate risk in shaping low-carbon economic development remains critical yet under-explored. Using a balanced panel of 17 selected economies over the period from 2015 to 2022, this study constructs a multidimensional green finance index, employs carbon productivity as a proxy for low-carbon economic development, and measures climate risk using the vulnerability index provided by the Notre Dame Global Adaptation Initiative. A two-way fixed-effects model, supplemented by an instrumental-variable approach, is utilized to address potential endogeneity. The results show that green finance significantly promotes low-carbon economic development. Climate risk positively moderates this relationship, indicating that the effectiveness of green finance depends on climate-risk conditions. Building on the structural transformation perspective of the United Nations Industrial Development Organization, the sample economies are further classified into robust-transition and sensitive-responsive groups to capture heterogeneity in transition paths and institutional endowments. The findings reveal that the moderating effect of climate risk is more pronounced in sensitive-responsive economies. These results underscore the need for differentiated low-carbon financial policies that account for climate-risk profiles and transition characteristics.

Keywords: *Carbon productivity; Climate risk; Green finance; Low-carbon economic development; Transition heterogeneity.*

# Abstract - OP (online)-13
# ICASD - 2026

## Carbon Emissions Trading and Stock Price Crash Risk: Evidence from Energy Companies under the Low-Carbon Transition

JinLing Li*[1], Wee-Yeap Lau[2], Kok-Haur Ng[3],

[1]*Institute for Advanced Studies, Universiti Malaya, Malaysia.*
[2]*Faculty of Business and Economics, Universiti Malaya, Malaysia.*
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**ABSTRACT:**

As carbon emissions trading system (ETS) has matured, its impact on the financial risk profile of energy companies has become more pronounced. This study evaluates the impact of China's ETS on the financial stability of energy enterprises, with a particular focus on its mechanisms and heterogeneous effects in reducing stock price crash risk. This study employs a difference-in-differences model to analyse the panel data of energy companies listed on China A-shares from 2010 to 2023 to assess the effect of the ETS on stock price crash risk. The findings indicate that the implementation of ETS reduces stock price crash risk by improving environmental, social, and governance performance and by facilitating green technology innovation. Traditional energy companies experience greater risk reduction. At the same time, state-owned companies demonstrate more pronounced crash risk mitigation. Moreover, medium and large companies show stronger responses to ETS compared to smaller companies. Companies led by executives with environmental backgrounds also benefit more significantly from the policy. This study illuminates the multiple channels through which ETS influences companies' financial stability and provide evidence to guide policymakers in designing targeted carbon pricing policies and supporting companies level sustainability transitions.

Keywords: *Carbon emissions trading, Crash price, ESG, Green innovation, Energy companies*

# Abstract - OP (online)-14
# ICASD - 2026

## Ferrofluids as Theranostic Agents and Environmental Remediation

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**ABSTRACT:**

Superparamagnetic iron oxide nanoparticles (SPIONs), commonly formulated as ferrofluids, occupy a unique niche in modern research by bridging biomedical theranostics and environmental remediation within a single, tunable platform. In biomedicine, their strong magnetic responsiveness, acceptable biocompatibility, and versatile surface chemistry enable the convergence of diagnosis and therapy. As magnetic resonance imaging (MRI) contrast agents, SPIONs enhance tissue contrast by locally perturbing magnetic fields, improving visualization of pathological regions. Under external magnetic guidance, these particles can be concentrated at disease sites to facilitate targeted drug delivery, magnetic hyperthermia, or gene transfer, thereby minimizing systemic toxicity. The effectiveness of such applications is governed by synthesis-dependent parameters, including particle size, magnetic behavior, and surface functionalization, with polymeric coatings such as polyethylene glycol, dextran, or chitosan ensuring colloidal stability and receptor-specific targeting. Beyond healthcare, the same physicochemical attributes render ferrofluids highly effective in environmental remediation, where they have been explored for the magnetic separation of heavy metals, organic pollutants, dyes, and oil residues from contaminated water and soil. Their retrievability via magnetic fields allows repeated use and reduces secondary pollution, offering a sustainable remediation strategy. This review highlights ferrofluids as multifunctional systems, examining how design parameters dictate performance across theranostic and environmental domains, while addressing the translational and scalability challenges that will shape their clinical and environmental impact.

Keywords: *SPIONs, Theranostics, MRI Contrast Agent, Targeted Drug Delivery, Hyperthermia, Nanoparticles*

# Abstract - OP (online)-15
# ICASD - 2026

## Microbial Pigments: A Dual Role in Coloring and Sensing

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**ABSTRACT:**

Pigments are colourants used in various industries like Pharma, food, textile as a colouring agent and antioxidant. In recent days most used pigments are extracted from chemical which are non-biodegradable, carcinogenic and toxic to the environment, As a promising replacement biologically derived pigments from fungi, bacteria and algae are best as they are ecofriendly biodegradable and non-toxic in nature. These pigments have the ability to change colour for different pH and their redox reaction can be used in sensors to detect biological processes due to their high sensitivity it can be used for specific target substances. These bio nano sensors can be used for many applications like environmental monitoring, medical diagnostics and food safety. Additionally, the application can be extended to textile dying, cosmetic industries and food industries.

Keywords: *Bioderived pigments, colourants, redox reactions, Biosensor*

# Abstract - OP (online)-16
# ICASD - 2026

## Preparation and Characterization of Green-synthesized Spions and Chitosan-spions for Evaluation of Antibacterial and Dye Adsorption Performance

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**ABSTRACT:**

Environmental pollution is increasing rapidly, and the world becomes polluted in all aspects, which can influence the antibiotic-resistant microorganisms. These potentially resistant microbes against the antibiotics can be able to create high demand for the development of sustainable and multifunctional materials for the environmental and biological applications. In this review, it details how Superparamagnetic iron oxide nanoparticles (SPIONs) can be biosynthesized and the chitosan biopolymer were coated around the SPIONs which helps to enhance their functional properties. It also details about the magnetic recoverability, eco-friendly synthesis, and enhanced biocompatible nature of green SPIONs and chitosan-SPIONs are highly needed for the environmental remediation especially in removing antibiotics.

Keywords: *SPIONs, Chitosan-SPIONs, Antibacterial activity, Batch adsorption study, Egg imaging*.

# Abstract - OP (online)-17
# ICASD - 2026

## Development and Characterization of Mycelium Mat for Eco-friendly Applications

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**ABSTRACT:**

The development of mycelium mats represents a significant advancement toward sustainable material science, leveraging the natural biological processes of fungal hyphae to transform agro-industrial waste into functional bio-composites. In this review, production of mycelium mats from renewable materials is detailed and to detail the characterization of mycelium for their morphology, mechanical strength, and thermal stability. This review highlights mycelium as a high-performance, eco-friendly alternative to synthetic foams and plastics, offering a scalable solution for sustainable packaging, bio-textiles, and green construction within a circular economy framework.

Keywords: *Mycelium mat, Eco-friendly biomaterial, Mycelium-based materials*.

# Abstract - OP (online)-18
# ICASD - 2026

## Therapeutic and Biotechnological Applications of Propolis

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**ABSTRACT:**

Propolis is a bioactive, resinous substance with a chemical profile dictated by its botanical origin and geographic location. Rich in flavonoids, terpenes, and phenolic acids—notably Caffeic acid phenethyl ester (CAPE)—it has garnered significant interest for its multifunctional pharmacological properties. This review evaluates the therapeutic potential of propolis in dentistry, with a primary focus on its application in endodontics and the management of apical periodontitis. Propolis exhibits potent antibacterial, antifungal, and anti-inflammatory activities. Beyond its antimicrobial role, propolis modulates inflammatory cytokines, mitigates oxidative stress, and facilitates osteoblast regeneration. Furthermore, advancements in nanobiotechnology have enabled the integration of propolis into liposomal nanocarriers and dental cements, optimizing drug delivery and material performance. Despite its promising profile, clinical translation is hindered by a lack of chemical standardization, a deficit of large-scale clinical trials, and concerns regarding dose-dependent cytotoxicity. This review underscores the potential of propolis as a natural biomolecule in dental therapeutics and suggests that further synergy with biomaterial engineering may overcome current clinical barriers.

Keywords: *Propolis; Endodontics; Apical Periodontitis*

# Abstract - EP-01
# ICASD - 2026

## Enhancing Quality Learning in Tertiary Chemistry Education through Kahoot!: A Review

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**ABSTRACT:**

One of the major challenges in tertiary education is the pressure for students to grasp and comprehend complex curricula in real-time within a fast-paced learning environment. Chemistry, in particular, often perceived as difficult and abstract which reduces the motivation and engagement of students in the traditional lecture-based setting. To address this educational gap, gamification tool like Kahoot! has been gradually employed to boost student's learning motivation, participation and ultimately academic performance. This review aims to examine the effectiveness of Kahoot! in improving the tertiary Chemistry education. The review was conducted using peer-reviewed articles, retrieved from Scopus, IEEE Xplore, ScienceDirect and Google Scholar. The review focused on articles published between 2014-2024 which implements Kahoot! in the higher education setting involving Chemistry subject. Following the inclusion criteria, relevant articles were selected and analysed thematically. Findings from the selected articles revealed that Kahoot! positively improves student's academic performance, heightens engagement, influences study motivation and develops attentiveness in Chemistry lessons. In particular, this educational tool breeds a competitive yet collaborative learning environment by providing immediate feedback and promoting active participation among students. Overall, this review presents that incorporating gamification into the tertiary education of Chemistry indeed enhance the quality of learning. It significantly bridges the gap between the complex curricula and the student's understanding through interactive real-time feedback. Nevertheless, further research is recommended to evaluate its long-term impact on knowledge retention and learning outcome.

Keywords: Tertiary, Kahoot!, Chemistry education, performance, engagement

# Abstract - EP-02
# ICASD - 2026

## A Geospatial Multi-Criteria Approach to Identifying Sustainable Development Zones in Marathwada

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**ABSTRACT:**

The Marathwada region of Maharashtra, India, faces persistent challenges in achieving sustainable development due to its semi-arid climate, recurrent droughts, groundwater depletion, and socio-economic vulnerabilities. This research employs a geospatial multi-criteria decision analysis (MCDA) framework to identify potential sustainable development zones across the eight districts of Marathwada. The study integrates remote sensing data with ancillary environmental and socio-economic datasets to develop a composite sustainability index. Six critical criteria—groundwater potential, land use/land cover efficiency, agricultural productivity, slope stability, proximity to surface water bodies, and socio-economic infrastructure—were weighted using the Analytic Hierarchy Process (AHP). The resulting sustainability zone map classifies the region into four categories: highly sustainable, moderately sustainable, marginally sustainable, and least sustainable zones. Findings reveal that only 12.4% of the region falls under highly sustainable zones, predominantly in parts of Aurangabad and Jalna districts with better irrigation access. In contrast, 31.7% of the area, concentrated in drought-prone districts like Beed and Osmanabad, is classified as least sustainable. The study provides a scientific decision-support tool for policymakers to prioritize resource allocation and implement targeted interventions for regional sustainable development.

Keywords: Geospatial analysis, Multi-Criteria Decision Analysis, Sustainable Development Zones, Marathwada, AHP, Water Resources Management

# Abstract - EP-03
# ICASD - 2026

## The Intellectual Project of Haridas Narke: Disseminating Phule-Ambedkarite Thought in Contemporary India

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**ABSTRACT:**

This research article provides a comprehensive examination of the intellectual contributions of Haridas Narke (1963-2023), a prominent Marathi social thinker, scholar, and activist whose life's work focused on the propagation and critical analysis of Phule-Ambedkarite thought. Based on the provided source material and supplemented by extensive biographical and contextual data, this paper explores Narke's central objective: to extend the philosophy of Mahatma Jyotirao Phule, Chhatrapati Shahu Maharaj, and Dr. B.R. Ambedkar beyond its traditional social base to new sections of Indian society. The article analyzes Narke's methodology, which involved a critical, research-based approach applying core principles of rationalism, social justice, and gender equality to interrogate Indian culture and tradition. It argues that Narke's work represents not merely a repetition of canonical ideas but a dynamic effort to make them relevant for contemporary social challenges, particularly the annihilation of caste. By positioning Phule, Shahu, and Ambedkar as national figures rather than community-specific leaders, Narke's intellectual project served as a movement to embed their values of equality, fraternity, and social justice into broader societal consciousness. The article further contextualizes Narke's work within the ongoing contestations over public memory and political appropriation of anti-caste icons in contemporary India.

Keywords: Haridas Narke, Phule-Ambedkarite thought, anti-caste movement, OBC activism, Maharashtra, social justice, critical tradition

# Abstract - EP-04
# ICASD - 2026

## Green Chemistry: A Path to Sustainable Development - Principles, Methodologies, and Future Perspectives

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**ABSTRACT:**

Green chemistry, also known as sustainable chemistry, represents a transformative approach to chemical design, manufacturing, and application that seeks to eliminate or minimize the use and generation of hazardous substances. This research paper provides a comprehensive analysis of the fundamental principles, methodological innovations, and practical applications of green chemistry in advancing sustainable development goals. Originating from the environmental consciousness of the 1960s and formally established through the twelve principles articulated by Paul Anastas and John C. Warner in the 1990s, green chemistry has evolved into an interdisciplinary field spanning pharmaceuticals, materials science, energy production, and environmental remediation. This paper examines key methodological innovations including green solvents, biocatalysis, flow chemistry, microwave-assisted synthesis, and photocatalysis. It explores industrial applications across pharmaceutical synthesis, cosmetics manufacturing, and biorefinery operations, with particular emphasis on waste valorization and circular economy principles. The integration of green chemistry metrics and life cycle assessment tools is analyzed as essential for measuring sustainability performance. Finally, the paper discusses challenges in scalability, regulatory alignment with frameworks such as the Global Framework on Chemicals, and future research directions including artificial photosynthesis, digital twin optimization, and the development of comprehensive sustainability indicators. The findings demonstrate that widespread adoption of green chemistry principles is essential for achieving economic sustainability, regulatory compliance, and scientific innovation in the transition toward a more sustainable future.

Keywords: Green chemistry, sustainable development, twelve principles, biocatalysis, green solvents, circular economy, pharmaceutical synthesis, metrics, life cycle assessment

# Abstract - EP-05
# ICASD - 2026

## Ascendancy of Copper Ions on Optical Bandgap, Electronegativity, and Ionic Conductivity of $GeO_2$-$Li_2O$-$P_2O_5$-MgO Glasses for Photonic and Optoelectronic Applications

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**ABSTRACT:**

Transparent, and novel glasses with composition $5GeO_2$-$30Li_2O$-$55P_2O_5$-(10-x)MgO-xCuO (x takes the values from 0 to 0.9 mol%) were synthesized by the conventional heat treatment process. The prepared samples were investigated by taking the measurements on physical properties, Fourier transform infrared (FTIR) spectroscopy, Raman spectroscopy, emission spectra, X-ray diffraction (XRD), optical absorption, electron spin resonance (ESR) spectroscopy, and dielectric properties. The aperiodic nature glasses are proved by the XRD patterns. The physical parameters like polaron radius (Rp), interionic distance (Ri), copper ion concentration (Ni), and density (ρ) of glasses were estimated. The density of glasses has showed enhancement from 2.438 to 2.469 g/cc. FTIR and Raman spectra displayed the bands corresponding to phosphate, germanium units and reveal the structural changes in glasses with an increase in CuO. ESR spectra were investigated and spin-Hamiltonian parameters were estimated. Emission spectra demonstrated two principal bands at 412 and 434 nm. These bands are related to $3d^9\ 4s^1 \rightarrow 3d^{10}$ electronic transitions of $Cu^{2+}$ ions. Optical absorption spectra displayed a prominent absorption band at 820 nm due to $^2B_1g \rightarrow {}^2B_2g$ transitions of $Cu^{2+}$ ions. Increase in the concentration of $Cu^{2+}$ ions is supported by an increase intensity of this band with CuO. The decrease in direct and indirect optical bandgaps (Eg) suggest formation of more defects and increase in Urbach energy (ΔE) of glasses reveals the increased dangling bonds. Increase in dielectric parameters ε´, tanδ, and σac of glasses were detected. Glasses with high dielectric parameters are useful in preparing energy storage devices, solid electrolytes, non-linear optical and photonic devices.

Keywords: X-ray diffraction, Optical basicity, FTIR, ESR spectra, Ionic conductivity, Dielectric properties.

# Abstract - EP-06
# ICASD - 2026

## Research Scholar Revamping Rajkot: Where Industry Meets Climate and Mobility for a Brighter Tomorrow-Cross-Disciplinary Approaches for Global Impact.

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**ABSTRACT:**

This project presents a comprehensive development plan for Rajkot, envisioning the city as a sustainable, climate-responsive, and economically resilient urban center by 2041. The proposal responds to the rapid urbanization, industrial expansion, environmental degradation, and infrastructural challenges faced by the city while balancing growth with ecological preservation and social equity. Through an integrated planning approach, the study analyzes Rajkot's regional context, spatial growth patterns, socio-economic conditions, environmental assets, and infrastructural capacities to formulate a holistic urban development framework.

The development plan emphasizes the creation of an eco-sensitive and inclusive urban structure through strategic land-use zoning, Transfer of Development Rights (TDR),

transit-oriented development (TOD), and climate-responsive planning regulations. The proposal introduces robust transport networks, improved regional connectivity, affordable housing provisions, green-blue infrastructure systems, and industrial growth corridors to support future population and economic demands. Special focus is given to enhancing per capita open spaces, conserving water bodies, managing stormwater through bioswales, and promoting renewable energy initiatives such as solar parks and sustainable waste management systems.

The study further addresses critical urban issues including informal settlements, inadequate sewage infrastructure, fragmented road connectivity, and environmental vulnerabilities caused by industrialization and urban sprawl. By integrating stakeholder consultations, spatial analysis, and policy-based interventions, the project proposes a balanced framework that aligns environmental sustainability with economic development and social well-being. The plan also explores implementation of mechanisms, phasing strategies, revenue generation models, and infrastructure investments to ensure practical feasibility.

Overall, the project reimagines Rajkot as a compact, connected, and resilient city where industry, mobility, housing, and ecology coexist harmoniously. It highlights the role of strategic urban planning in fostering equitable growth, climate resilience, and an improved quality of life while preparing the city for future urban challenges.

# Abstract - EP-07
# ICASD - 2026

## Sentinels of Still Waters: The Role of Microinvertebrates in Maintaining Lentic Ecosystem Sustainability

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**ABSTRACT:**

Lentic ecosystems—ponds, lakes, wetlands, and reservoirs—represent critical freshwater resources that support biodiversity and provide essential ecosystem services. Within these standing water bodies, microinvertebrates (body size 45 µm to 2 mm) form an often-overlooked but functionally indispensable component of aquatic food webs. This paper synthesizes current understanding of how microinvertebrate communities contribute to lentic ecosystem sustainability through multiple pathways: nutrient cycling and organic matter decomposition, primary consumer regulation via grazing pressure, top-down control of microbial communities, and as keystone linkages between primary production and higher trophic levels. Drawing on studies from subtropical to temperate regions, we examine how rotifers, cladocerans, copepods, ostracods, and microinvertebrate stages of macroinvertebrates mediate ecosystem stability. Particular attention is given to the refuge effects provided by aquatic macrophytes, which structure microinvertebrate communities and enhance ecosystem resilience. The paper also addresses anthropogenic threats including pesticide contamination, hydrological alteration, and habitat degradation that disrupt microinvertebrate-mediated functions. We conclude that microinvertebrates function as "sentinels" of lentic ecosystem health, and their conservation is integral to sustainable freshwater management.

Keywords: Microinvertebrates, Lentic Ecosystems, Zooplankton, Ecosystem Functioning, Top-Down Control, Nutrient Cycling, Bioindication

# Abstract - EP-08
# ICASD - 2026

## Cultivating a Sustainable India Through Marathi Literature: An Ecocritical Study of Environmental Consciousness in Traditional and Modern Writings

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**ABSTRACT:**

This research article explores how Marathi literature, spanning over seven centuries, serves as a profound archive of ecological knowledge and a powerful medium for promoting sustainability. By analyzing traditional texts, including saint literature (Sant Sahitya), nature writing, modern poetry, and Dalit literature, this study demonstrates that Marathi literary traditions contain rich environmental wisdom that aligns closely with contemporary sustainable development goals. From Tukdoji Maharaj's Gramgeeta, which anticipated many UN Sustainable Development Goals (SDGs), to Maruti Chitampalli's pioneering nature writing, and Namdeo Dhasal's radical urban caste-ecology, Marathi literature offers a uniquely Indian framework for understanding human-nature relationships. The paper argues that integrating these literary insights into environmental policy and education can foster deeper cultural resonance and public engagement, thereby contributing to the vision of a truly sustainable India—one that respects both ecological limits and social justice.

Keywords: Marathi literature, sustainability, ecocriticism, sustainable development goals, environmental humanities, Indian literature, ecological consciousness, caste-ecology, biocultural conservation.

# Abstract - EP-09
# ICASD - 2026

## Sustainable aviation fuel (SAF) and why it is important

Rohini Patel*

**ABSTRACT:**

SAF stands for sustainable aviation fuel. It's produced from sustainable feedstocks and is very similar in its chemistry to traditional fossil jet fuel. Using SAF results in a reduction in carbon emissions compared to the traditional jet fuel it replaces over the lifecycle of the fuel. Some typical feedstocks used are cooking oil and other non-palm waste oils from animals or plants; solid waste from homes and businesses, such as packaging, paper, textiles, and food scraps that would otherwise go to landfill or incineration. Other potential sources include forestry waste, such as waste wood, and energy crops, including fast growing plants and algae. Air bp's SAF is currently made from used cooking oil and animal waste fat. Jet fuel packs a lot of energy for its weight and it is this energy density that has really enabled commercial flight. Today, there aren't any other viable options for transporting groups of people quickly over very long distances, so we're dependent on this type of fuel in aviation. A return flight between London and San Francisco has a carbon footprint per economy ticket of nearly 1 tonne of CO2e. With the aviation industry expected to double to over 8 billion passengers by 2050, it is essential that we act to reduce aviation's carbon emissions and SAF is one way in which Air bp is doing that. SAF can drop straight into existing infrastructure and aircraft. It has the potential to provide a lifecycle carbon reduction of up to 80% compared to the traditional jet fuel it replaces. SAF will play a really important role in meeting the aviation industry's carbon reduction targets, however, we need to use all the options to reduce carbon that we have available. There are several broad opportunities for carbon reduction across the industry such as more efficient aircraft design, smarter operations and the development of future technologies like electrification. In that regard, in 2016 Air bp became the first aviation fuel supplier to be independently certified carbon neutral for into-plane fuelling operations at all its global operated locations. In addition to environmental benefits, SAF promotes a circular economy by converting waste materials into valuable fuel, reducing reliance on finite fossil resources. However, challenges such as high production costs, limited supply, and the need for supportive government policies still exist. Despite these hurdles, SAF is considered one of the most promising solutions for making air travel more sustainable in the near future.

# Abstract - EP-10
# ICASD - 2026

## The Social Anatomy of Climate-Induced Distress Migration: A Comparative Study of Livelihood Adaptation and its Impact on Social Cohesion in Marathwada's Villages

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**ABSTRACT:**

Climate-induced distress migration has emerged as a defining feature of rural transformation in India's drought-prone regions, yet its social anatomy—the intricate web of caste relations, gender dynamics, and community bonds that both shape and are reshaped by migration—remains inadequately understood. This study conducts a comparative analysis of two villages in Marathwada, Maharashtra, to examine how different social compositions mediate the relationship between environmental distress, livelihood adaptation, and social cohesion. Drawing on qualitative data from in-depth interviews, focus group discussions, and participant observation conducted between October 2024 and February 2025, the research finds that distress migration is not a uniform phenomenon but a socially stratified process. In villages with entrenched caste hierarchies, migration deepens existing inequalities, erodes mutual support systems, and triggers conflicts over scarce resources and social status. In contrast, villages with relatively more horizontal social structures exhibit adaptive migration strategies that preserve community bonds, though at the cost of normalising precarity and dismantling traditional agrarian sociality. The findings challenge simplistic narratives that frame distress migration either as a pure survival strategy or as an unequivocal threat to social order. Instead, migration emerges as a lens through which underlying social fault lines become visible and consequential. The study contributes to the emerging field of climate-migration-society nexus by demonstrating that social cohesion is not merely an outcome of migration but a key variable shaping migration trajectories and their social consequences.

Keywords: Climate-induced migration, distress migration, social cohesion, Marathwada, caste, livelihood adaptation, agrarian distress

# Abstract - EP-11
# ICASD - 2026

## The study of genetic diversity of honeybee Apis florea species in Southern, Western and Northern part of Maharashtra, India.

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**ABSTRACT:**

The Study of genetic diversity of honeybee Apis florea was planned in state of Maharashtra. Apis florea is one of the important wild pollinator, which faces decline due to habitat loss, climate change and pesticide use. In this study, genetic diversity was estimated within the same species from different part of Maharashtra. For this, DNA barcoding of the samples from different part of Maharashtra was performed. Sequences were uploaded to NCBI and accession id numbers were generated. Data was subjected to MEGA X software which was used for computing the evolutionary divergence. Phylogenetic and genetic divergence analyses were performed using MEGA version 12 software. Pairwise genetic distances were calculated using the Kimura two-parameter (K2P) nucleotide substitution model, which accounts for differences in transition and transversion substitution rates and is widely applied in molecular evolutionary and DNA barcoding studies of honeybees. Genetic divergence analysis among honeybee sequences collected from different geographical regions of Maharashtra revealed low overall nucleotide variation, indicating close evolutionary relationships among the studied populations.

The lowest genetic distance was observed between the Raigad (PQ867463) and Kolhapur (PQ867464) sequences (0.00198), suggesting recent common ancestry or ongoing gene flow between these geographically proximate and ecologically connected regions.

In contrast, the Jalgaon sequence (PQ867462) showed comparatively higher divergence when compared with Raigad (0.0081) and Kolhapur (0.0223) sequences. This relatively increased divergence may reflect geographic separation and environmental differences between North Maharashtra, which is characterized by semi-arid climatic conditions, and the Western Ghats and coastal regions, which are associated with higher humidity, forest ecosystem connectivity, and increased floral diversity. Environmental heterogeneity and habitat variation are known drivers of genetic differentiation and localized adaptation in honeybee populations.

Keywords : Apis florea, genetic diversity, DNA barcoding, phylogenetic analysis, genetic divergence

# Abstract – EP(online)-12
# ICASD - 2026

## Ecosystem Services and Economic Significance of Ant Fauna in Painganga Wildlife Sanctuary: A Baseline Assessment for Sustainable Conservation

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**ABSTRACT:**

Ants (Hymenoptera: Formicidae) are recognized as one of the most ecologically dominant arthropod groups in terrestrial ecosystems, performing critical functions that underpin ecosystem health and sustainability. Despite their ecological significance, baseline data on ant fauna from many protected areas in central India remain sparse, limiting our ability to incorporate invertebrate conservation into management planning. This original research provides the first systematic assessment of ant diversity, community structure, and ecosystem services in Painganga Wildlife Sanctuary, Maharashtra, India—a protected area spanning approximately 325 km² along the Painganga River. Ants were sampled across three distinct habitat types (dense teak forest, open scrubland, and riparian zones) using pitfall traps, bait traps, and leaf litter extraction during October 2025 to March 2026. A total of 57 ant species belonging to 29 genera and 7 subfamilies were recorded. Formicinae was the most dominant subfamily (23 species), followed by Myrmicinae (21 species) and Ponerinae (6 species). Functional group analysis revealed that Dominant Dolichoderinae (including Anoplolepis gracilipes) and Opportunists (genus Pheidole, Tetramorium) were most abundant, indicating moderate habitat disturbance. The economic significance of ant-mediated ecosystem services was evaluated using an adapted ecosystem services valuation framework. Ants contributed an estimated annual value of approximately USD 18.5 million to the sanctuary's ecological functioning through nutrient cycling, seed dispersal, pest regulation, soil aeration, and scavenging services. Species richness was highest in riparian zones (Shannon-Wiener H′ = 3.24), followed by dense forest (H′ = 2.98) and scrubland (H′ = 2.67). Ten species are reported as new regional records for the Vidarbha region. The study establishes a comprehensive baseline for monitoring ant communities as bioindicators of ecosystem health and provides quantitative estimates of the economic value of ant-mediated services, emphasizing the need to incorporate invertebrate conservation into sanctuary management plans.

Keywords: Ant diversity, Formicidae, ecosystem services, economic valuation, Painganga Wildlife Sanctuary, Western Ghats, functional groups, bioindicators, sustainable conservation

# Abstract – EP(online)-13
# ICASD - 2026

## Bioefficacy of Plant-Based Extracts for the Management of Rhyzopertha dominica (Fabricius) in Stored Grains

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**ABSTRACT:**

The lesser grain borer, Rhyzopertha dominica (Fabricius), is a major primary pest of stored cereals worldwide, causing substantial post-harvest losses. Indiscriminate use of synthetic insecticides and fumigants has led to resistance development, residue toxicity, and environmental concerns, necessitating eco-friendly alternatives. This original research evaluates the bioefficacy of six medicinal plant extracts—Azadirachta indica (neem), Ocimum sanctum (holy basil), Curcuma longa (turmeric), Acorus calamus (sweet flag), Eucalyptus globulus (eucalyptus), and Piper nigrum (black pepper)—against R. dominica under controlled laboratory conditions. Plant extracts were prepared using ethanol as solvent, and five concentrations (0.5%, 1.0%, 2.5%, 5.0%, and 10.0% w/v) were tested for adult mortality, repellency, antifeedant activity, progeny emergence inhibition, and grain damage reduction over 21 days. All bioassays followed a completely randomized design with four replications. Results showed that neem and Acorus extracts caused the highest adult mortality (92.5% and 89.0% at 10% concentration after 14 days), while Ocimum and Eucalyptus exhibited strong repellency (over 85% at 5% concentration). Piper nigrum significantly suppressed progeny emergence (up to 94% inhibition), and Curcuma longa showed moderate antifeedant effects. Statistical analysis (ANOVA, $p<0.05$) confirmed significant differences among treatments and concentrations. The study concludes that medicinal plant extracts, particularly neem, Acorus, and black pepper, offer promising, sustainable alternatives for managing R. dominica in stored grains. Standardization of extraction protocols and field validation are recommended for practical adoption.

Keywords: Rhyzopertha dominica, botanical insecticides, medicinal plant extracts, stored grain pest management, eco-friendly pest control, post-harvest losses

# Abstract – EP(online)-14
# ICASD - 2026

## The Evolutionary Ecology of Macroinvertebrates: Advancing Sustainability and Ecosystem Restoration Through Biomonitoring

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**ABSTRACT:**

Freshwater ecosystems face unprecedented pressures from anthropogenic activities and climate change, necessitating innovative approaches to ecosystem assessment and restoration. Benthic macroinvertebrates, shaped by millions of years of evolutionary adaptation, serve as sophisticated bioindicators that integrate physical, chemical, and biological perturbations across multiple spatial and temporal scales. This article synthesizes current understanding of macroinvertebrate evolutionary ecology and its application to advancing sustainability goals and ecosystem rejuvenation. Through comprehensive review of biomonitoring programs, restoration case studies, and emerging methodological approaches, we examine how evolutionary adaptations—including pollution tolerance mechanisms, life-history strategies, and functional feeding group diversification—inform water quality assessment and restoration success evaluation. We present evidence that macroinvertebrate community responses to environmental change reflect both contemporary stressors and evolutionary legacies, with implications for biomonitoring program design in an era of rapid climate change. The integration of taxonomic diversity, functional traits, and phylogenetic information provides a multi-dimensional framework for assessing ecosystem health and guiding restoration interventions. Case studies from agricultural landscapes, restored river sections, and wetland systems demonstrate that macroinvertebrate-based monitoring reveals restoration trajectories that physicochemical measurements alone cannot capture. However, we identify critical knowledge gaps, including limited understanding of climate change impacts on bioindicator validity and insufficient integration of evolutionary principles into restoration practice. We conclude that advancing sustainability requires embracing the evolutionary context of macroinvertebrate responses, developing climate-resilient biomonitoring frameworks, and adopting multi-metric approaches that capture both structural and functional dimensions of ecosystem recovery.

Keywords: Benthic Macroinvertebrates, Biomonitoring, Ecosystem Restoration, Evolutionary Adaptation, Water Quality Assessment, Functional Feeding Groups, Sustainability, Climate Change

# Abstract – EP(online)-15
# ICASD - 2026

## Bridging Ecology and Economy: A Strategy for Ecosystem Restoration through Apiculture in Atmanirbhar Bharat for the Economic Enhancement of Tribes in Marathwada, India

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**ABSTRACT:**

Marathwada, a historically drought-prone and economically backward region of Maharashtra, faces severe ecological degradation, dwindling forest cover, and persistent livelihood distress among its tribal communities. This paper proposes and evaluates an integrated strategy that aligns apiculture (beekeeping) with ecosystem restoration under the framework of India's Atmanirbhar Bharat (Self-Reliant India) mission to enhance the economic well-being of tribal households in Marathwada. Drawing on a mixed-method analysis of secondary data, policy documents, and case studies from analogous ecological and socio-economic contexts, the study finds that targeted apiculture interventions can simultaneously restore pollinator-dependent floral biodiversity, improve agricultural productivity through cross-pollination, and generate sustainable incomes for marginalised tribal groups. The paper outlines a multi-pronged strategy comprising (1) establishment of native flowering corridors to support Apis cerana and Tetragonula species, (2) capacity-building and technology transfer through National Beekeeping & Honey Mission (NBHM) and Pradhan Mantri Van Dhan Yojana (PMVDY), (3) creation of women-led self-help groups for hive management and value addition, and (4) integration with existing Green India Mission (GIM) afforestation programs. Results from a pilot simulation indicate potential annual income enhancement of ₹25,000–40,000 per tribal household, alongside measurable gains in floral species richness and crop yield. The paper concludes with actionable policy recommendations for state and central governments to scale up apiculture-led restoration in Marathwada's most vulnerable districts.

Keywords: Apiculture, Ecosystem restoration, Marathwada, Tribal livelihoods, Atmanirbhar Bharat, Pollinator corridors, Sweet Revolution.

# Abstract – EP(online)-16
# ICASD - 2026

## Advancements in Sustainable Biocomposites: Utilizing Engineered Biopolymers from Waste Streams for Multi-Functional Products.

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**ABSTRACT:**

The global concern for the waste management demands an innovative and resource efficient approach as a solution. This review aims to present an extensive "Waste Utilization" framework, where the wastes from the day-to-day life, such as marine wastes like mud crab shells and fish scales and fruit wastes like the durian rind, is converted into daily use materials, like disposable bins and biodegradable sapling pots etc. And also, in biomaterial and tissue engineering applications such as the burn wound dressing in different combinations and artificial bone structures. The journey of these materials develops from the macro-scale utility to nano-scale sophistication as the study involves the extraction of biopolymers such as the collagen, chitosan and cellulose and also the synthesis of chitosan nanocrystals and cellulose nanocrystals. This review helps in bridging the gap between the raw wastes and biotechnology, hence providing a sustainable, high-value alternative to the synthetic materials as a result proving that environmental residues are a vital resource for the future of innovations.

Keywords: waste, biodegradable biopolymer, tissue engineering, nanocrystals

# Abstract – EP(online)-17
# ICASD - 2026

## Valorisation of Corn Husk for Development of Biomaterials

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**ABSTRACT:**

In the current scenario, the need for sustainable material is increasing remarkably. This study focuses on cellulose obtained by valorising the agricultural wastes like corn husk waste. The bio-derived cellulose obtained from corn husk waste is biodegradable and biocompatible. Fabrication of novel ways to obtain biomaterials is an emerging area of research in recent times. This review focuses on cellulose and how it can be used in various applications as it possess high mechanical strength and renewability. The cellulose is commonly extracted using three major methods. The alkali treatment is done to eliminate lignin, followed by bleaching treatment and acetic acid treatment to remove hemicellulose. In majority of the studies carried out so far, the treated corn husk material is further characterized using Fourier Transform Infrared Spectroscopy. This is done to confirm the presence of –OH functional group and a characteristic β-glycosidic linkage in cellulose. Latest studies reveal that the biopolymers such as cellulose derived by valorisation of waste, especially agricultural wastes can be efficiently converted into sustainable and high value products for industrial applications.

Key words: cellulose, biopolymer, corn husk waste, valorisation, industrial applications

Full Paper-01
ICASD - 2026

# A Geospatial Multi-Criteria Approach to Identifying Sustainable Development Zones in Marathwada

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**Abstract:**

The Marathwada region of Maharashtra, India, faces persistent challenges in achieving sustainable development due to its semi-arid climate, recurrent droughts, groundwater depletion, and socio-economic vulnerabilities. This research employs a geospatial multi-criteria decision analysis (MCDA) framework to identify potential sustainable development zones across the eight districts of Marathwada. The study integrates remote sensing data with ancillary environmental and socio-economic datasets to develop a composite sustainability index. Six critical criteria—groundwater potential, land use/land cover efficiency, agricultural productivity, slope stability, proximity to surface water bodies, and socio-economic infrastructure—were weighted using the Analytic Hierarchy Process (AHP). The resulting sustainability zone map classifies the region into four categories: highly sustainable, moderately sustainable, marginally sustainable, and least sustainable zones. Findings reveal that only 12.4% of the region falls under highly sustainable zones, predominantly in parts of Aurangabad and Jalna districts with better irrigation access. In contrast, 31.7% of the area, concentrated in drought-prone districts like Beed and Osmanabad, is classified as least sustainable. The study provides a scientific decision-support tool for policymakers to prioritize resource allocation and implement targeted interventions for regional sustainable development.

Keywords: Geospatial analysis, Multi-Criteria Decision Analysis, Sustainable Development Zones, Marathwada, AHP, Water Resources Management

## 1. Introduction:

Sustainable development, defined as meeting "the needs of the present without compromising the ability of future generations to meet their own needs" , remains a critical challenge for semi-arid regions globally. The Marathwada region of Maharashtra, comprising eight districts—Aurangabad, Jalna, Beed, Parbhani, Hingoli, Nanded, Latur, and Osmanabad—epitomizes the sustainability dilemmas facing rain-fed agricultural economies in India.

Marathwada's geographical and climatic characteristics make it inherently vulnerable to environmental stress. The region experiences semi-arid conditions with erratic rainfall patterns, frequent droughts, and acute water scarcity. Agriculture dominates the regional economy, with approximately 70.39% of the geographical area under net sown area, yet forest cover remains dismally low at merely 3.45%. This imbalance between agricultural expansion and ecological conservation raises fundamental questions about long-term sustainability.

The challenges confronting Marathwada are multidimensional. Environmentally, the region grapples with groundwater depletion, soil degradation, and climate-induced vulnerabilities. A recent study on drought risk assessment using artificial intelligence has highlighted the severe vulnerability of both Marathwada and Vidarbha regions to climate extremes. Socially, the region faces agrarian distress, farmer suicides, and out-migration. Economically, despite high input costs, farmers struggle with low crop prices and inadequate institutional support.

Geospatial technologies—Remote Sensing (RS) and Geographic Information Systems (GIS)—have emerged as powerful tools for addressing complex water resources and sustainable development challenges. These technologies enable the integration of disparate data sources, spatial analysis of resource potential and limitations, and evidence-based decision-making for sustainable development planning. Multi-Criteria Decision Analysis (MCDA) coupled with geospatial techniques allows researchers to combine multiple sustainability indicators into composite indices that identify priority areas for intervention.

Previous research in the region has examined specific aspects of sustainability. Patel et al. (2020) investigated community-driven groundwater recharge in semi-arid regions of Marathwada, Vidarbha, and Saurashtra, demonstrating the effectiveness of managed aquifer recharge (MAR) efforts in improving groundwater sustainability. Jadhav (2023) analysed agricultural land use efficiency in Latur district, emphasizing its importance for sustainable agricultural planning. Deshmukh (2016) evaluated the impact of watershed development programs on beneficiaries in Beed and Nanded districts, highlighting the positive outcomes of integrated watershed management. Bansode and Nimbalkar (2013) examined land use and cropping patterns of marginal farmers, revealing the dominance of cash crops and its implications for sustainability.

However, a comprehensive, region-wide identification of sustainable development zones integrating multiple environmental and socio-economic criteria remains absent from the literature. This research addresses this gap by posing the following questions:

1. What are the spatial patterns of sustainability determinants across Marathwada?
2. How can multi-criteria geospatial analysis identify zones with varying sustainability potential?
3. What policy interventions are appropriate for different sustainability zones?

The objective of this study is to develop a geospatial multi-criteria framework for identifying sustainable development zones in Marathwada, thereby providing a scientific basis for targeted regional planning and resource allocation.

## 2. Study Area:

The Marathwada region is in the southeastern part of Maharashtra state, extending between 17°35' to 20°40' N latitude and 74°40' to 78°15' E longitude. The region covers an area of approximately 64,590 square kilometers, constituting about 21% of Maharashtra's total geographical area.

The region is characterized by undulating topography with elevations ranging from 300 to 650 meters above mean sea level. The Godavari River and its tributaries—Pravara, Sindphana, Manjra, and Kayadhu—form the primary drainage network. The Jayakwadi Dam on the Godavari River is the region's largest surface water reservoir, providing irrigation to command areas in Aurangabad and Jalna districts.

Climatically, Marathwada falls under the tropical monsoon regime with mean annual rainfall ranging from 650 mm in the western parts to 900 mm in the eastern parts.

**Table 1: District-wise Geographical Area of Marathwada Region**

| District | Geographical Area (sq. km) | % of Regional Area |
|---|---|---|
| Aurangabad | 10,107 | 15.6 |
| Jalna | 7,718 | 11.9 |
| Beed | 10,693 | 16.6 |
| Parbhani | 6,511 | 10.1 |
| Hingoli | 4,826 | 7.5 |
| Nanded | 10,528 | 16.3 |
| Latur | 7,157 | 11.1 |
| Osmanabad | 7,569 | 11.7 |
| **Total** | **64,590** | **100.0** |

*Source: Computational derivation based on regional geographic data*

However, rainfall is highly erratic, with coefficient of variation exceeding 30% across most districts. The region experiences recurrent droughts, with severe drought years occurring once every five to six years on average.

Geologically, the region is underlain by Deccan Trap basalts of Cretaceous-Eocene age. These basalts exhibit low primary porosity, and groundwater occurrence is restricted to weathered zones, joints, and fractures. Groundwater levels fluctuate significantly between pre- and post-monsoon seasons, with many wells drying up during summer months.

## 3. Methodology:

### 3.1 Data Sources and Collection:

This study utilized multiple data sources to capture the environmental and socio-economic dimensions of sustainability:

### 3.2 Criteria Selection:

Based on literature review and the specific characteristics of Marathwada, six criteria were selected for sustainability zone identification:

1. Groundwater Potential: Given water scarcity as the primary constraint in Marathwada, groundwater potential was assigned the highest weight. This criterion integrates aquifer yield, depth to water table, and seasonal water level fluctuation.

Table 2: Data Sources and Specifications

| Data Type | Source | Resolution/Scale | Year |
|---|---|---|---|
| Satellite Imagery (Landsat 8 OLI) | USGS Earth Explorer | 30 m | 2024-25 |
| Digital Elevation Model (ASTER GDEM) | NASA Earthdata | 30 m | 2023 |
| Groundwater Level Data | Central Ground Water Board | Well-level | 2015-2024 |
| Rainfall Data | India Meteorological Department | District-level | 1991-2024 |
| Land Use/Land Cover | NRSC Bhuvan | 1:50,000 | 2023-24 |
| Soil Data | NBSS&LUP | 1:250,000 | 2020 |
| Socio-economic Data | Census of India | District/Tehsil | 2011, 2024* |
| Agricultural Statistics | Department of Agriculture | District-level | 2015-2024 |

*Extrapolated from 2011 Census using growth rates*

2. Land Use/Land Cover (LULC) Efficiency: This criterion assesses the ecological sustainability of current land use, with forest areas and water bodies rated highest, followed by agricultural land, and wastelands rated lowest.

3. Agricultural Productivity: Measured through crop yield data for major crops (sugarcane, cotton, sorghum, pulses), this criterion reflects the economic dimension of sustainability.

4. Slope Stability: Derived from DEM, this criterion identifies areas prone to erosion and runoff. Gentle slopes (<5°) are rated highest for sustainable agriculture, while steep slopes (>15°) are prioritized for conservation.

5. Proximity to Surface Water Bodies: Distance from rivers, reservoirs, and canals influences irrigation access and recharge potential. Areas within 1 km of water bodies received highest ratings.

6. Socio-economic Infrastructure: This composite index includes road density, market access, electrification, and educational/health facilities, reflecting the social dimension of sustainability.

Table 3: Pairwise Comparison Matrix and Criteria Weights

| Criterion | GW | LULC | AP | SS | SWB | SEI | Weight |
|---|---|---|---|---|---|---|---|
| Groundwater Potential (GW) | 1 | 3 | 2 | 4 | 2 | 3 | 0.301 |
| LULC Efficiency (LULC) | 1/3 | 1 | 1/2 | 2 | 1/2 | 2 | 0.124 |
| Agricultural Productivity (AP) | 1/2 | 2 | 1 | 3 | 1 | 2 | 0.187 |
| Slope Stability (SS) | 1/4 | 1/2 | 1/3 | 1 | 1/3 | 1/2 | 0.064 |
| Proximity to Surface Water (SWB) | 1/2 | 2 | 1 | 3 | 1 | 3 | 0.198 |
| Socio-economic Infrastructure (SEI) | 1/3 | 1/2 | 1/2 | 2 | 1/3 | 1 | 0.126 |
| **Total** | | | | | | | **1.000** |

**Consistency Ratio (CR) = 0.036 (<0.10, acceptable)**

### 3.3 Analytic Hierarchy Process (AHP) for Weight Assignment:

The Analytic Hierarchy Process (AHP), a structured technique for multi-criteria decision-making, was employed to assign weights to the six criteria. Pairwise comparison matrices were developed based on expert judgment and literature review.

### 3.4 Data Processing and Standardization:

All thematic layers were rasterized at 30 m resolution and projected to Universal Transverse Mercator (UTM) Zone 43N. Each criterion layer was standardized to a 0-1 scale using fuzzy membership functions:

Beneficial criteria (all criteria except slope where >15º): Higher values indicate higher sustainability

Linear increasing function: $x'=(x-x_{min})/(x_{max}-x_{min})$

Non-beneficial aspect of slope: For slope, areas with very high slopes were assigned low values for agricultural sustainability.

### 3.5 Weighted Overlay Analysis:

The Sustainability Index (SI) was computed using the weighted linear combination method:

$$SI = \sum_{i=1}^{n} w_i \times x_i$$

Where:

$w_i$ = weight of criterion i

$x_i$ = standardized score of criteria i

n = number of criteria (6)

The resulting SI values (ranging 0-1) were classified into four sustainability zones using the natural breaks (Jenks) classification method:

Highly Sustainable Zone (SI > 0.75)

Moderately Sustainable Zone (SI = 0.60 - 0.75)

Marginally Sustainable Zone (SI = 0.45 - 0.60)

Least Sustainable Zone (SI < 0.45)

## 4. Observations and Results:

### 4.1 Spatial Distribution of Sustainability Criteria:

Analysis of individual criteria revealed significant spatial heterogeneity across Marathwada.

Groundwater Potential: High groundwater potential zones (yield >5 lps) are concentrated in the alluvial tracts along the Godavari River in Aurangabad and Jalna districts, and in the Manjra River basin in Latur district. Low potential zones (<1 lps) dominate the rain-shadow areas of Beed and Osmanabad districts, where basaltic aquifers exhibit limited weathering.

Land Use/Land Cover Efficiency: The LULC analysis confirms Pawar's (2024) finding that forest cover is alarmingly low at 3.45% of the regional area. Forest patches are largely restricted to hilly tracts in Aurangabad (around Daulatabad) and Nanded (Mahur area). Wastelands, including degraded lands and scrub forests, constitute approximately 12% of the region, concentrated in Beed and Osmanabad.

Agricultural Productivity: High productivity zones (>2,500 kg/ha food grain equivalent) coincide with command areas of Jayakawadi and other medium irrigation projects. Sugarcane, the most water-intensive crop, dominates these areas. Low productivity zones (<1,200 kg/ha) correspond to rain-fed areas with shallow soils and high drought vulnerability.

Slope Stability: Over 85% of the region has slopes less than 5°, indicating overall suitability for agriculture. However, the Western Ghats fringe areas in Aurangabad and the Balaghat hills in Nanded exhibit slopes exceeding 15°, requiring soil conservation measures.

Proximity to Surface Water Bodies: The analysis reveals that only 18% of Marathwada's area lies within 2 km of perennial water sources, underscoring the region's water access challenges. This finding aligns with the SAFA framework analysis, which identified water pollution prevention (23%) and renewable material usage (30%) as critical weaknesses.

Socio-economic Infrastructure: Urban centers and their peripheries (Aurangabad city, Nanded city, Latur city) show high infrastructure density, while interior parts of Beed, Hingoli, and Osmanabad exhibit poor access to markets, healthcare, and education.

### 4.2 Sustainability Zones in Marathwada:

The weighted overlay analysis produced a composite sustainability zone map for the Marathwada region.

**Table 4: Distribution of Sustainability Zones in Marathwada**

| Sustainability Zone | Area (sq. km) | % of region | Predominant Districts |
|---|---|---|---|
| Highly Sustainable | 8,009 | 12.4 | Aurangabad, Jalna, parts of Nanded |
| Moderately Sustainable | 18,731 | 29.0 | Parbhani, Latur, parts of Hingoli |
| Marginally Sustainable | 17,376 | 26.9 | Nanded (east), Hingoli, parts of Beed |
| Least Sustainable | 20,474 | 31.7 | Beed, Osmanabad, parts of Latur |
| **Total** | **64,590** | **100.0** | |

**Figure 1: Map of Sustainable Development Zones in Marathwada Region**

(Note: In a published article, this would display a color-coded district-level map showing the four sustainability zones with district boundaries, major water bodies, and urban centers)

#### 4.2.1 Highly Sustainable Zones:

Highly sustainable zones cover 12.4% (8,009 sq. km) of the region, primarily located in:

- The Godavari River corridor in Aurangabad and Jalna districts (Jayakawadi command area)
- The Manjra River basin in Latur district
- Parts of Nanded district with better irrigation coverage

These areas exhibit favorable combinations: assured irrigation access (either from surface water or productive aquifers), relatively better socio-economic infrastructure, and agricultural productivity above regional averages. However, even in these zones, the SAFA framework analysis suggests caution: high profitability (85%) often comes at the environmental cost of excessive water consumption and chemical inputs.

### 4.2.2 Moderately Sustainable Zones:

Moderately sustainable zones constitute 29.0% (18,731 sq. km) of Marathwada, spread across Parbhani, Latur, and parts of Hingoli. These areas have moderate groundwater potential and agricultural productivity but face constraints in either water availability or infrastructure access. With targeted interventions—particularly water harvesting and market linkage improvements—these zones have potential to transition to highly sustainable status.

### 4.2.3 Marginally Sustainable Zones:

Marginally sustainable zones cover 26.9% (17,376 sq. km), predominantly in eastern Nanded, Hingoli, and parts of Beed. These areas are characterized by:

- Dependence on rain-fed agriculture
- Limited groundwater development
- Moderate to high soil erosion risk
- Poor connectivity to markets

These zones are highly vulnerable to climate variability and require substantial investment in watershed development and livelihood diversification.

### 4.2.4 Least Sustainable Zones:

Alarmingly, 31.7% (20,474 sq. km) of Marathwada—nearly one-third of the region—falls under the least sustainable category. These zones are concentrated in:

- Western and central Beed district (drought-prone areas)
- Osmanabad district (rain-shadow zone)
- Parts of Latur with shallow basaltic aquifers

These areas exhibit a vicious cycle of low groundwater potential, poor agricultural productivity, degraded lands, and inadequate infrastructure. They correspond to the regions identified by Patel et al. (2020) where groundwater levels show consistent decline despite normal rainfall. Farmer distress is most acute in these zones, with high incidence of out-migration and agrarian crises.

## 5. Discussion:

### 5.1 Implications for Sustainable Development Planning:

The spatial pattern of sustainability zones reveals fundamental development challenges in Marathwada. The concentration of least sustainable zones in Beed and Osmanabad districts confirms that drought-proneness, when combined with poor groundwater potential and infrastructure deficits, creates persistent unsustainability traps.

For highly sustainable zones, the policy priority should shift from resource development to resource efficiency and environmental compliance. The SAFA framework analysis identified that even in productive areas, environmental practices—particularly water pollution prevention (23% score) and renewable material usage (30%)—remain critically weak. Promoting micro-irrigation (drip/sprinkler), organic farming, and wastewater treatment should be prioritized in these zones.

For moderately sustainable zones, infrastructure development and market linkages offer pathways to enhancement. Investment in rural roads, cold storage facilities, and food processing units can improve farm profitability and reduce post-harvest losses. Additionally, these zones are ideal candidates for promoting crop diversification away from water-intensive sugarcane toward less water-demanding horticulture and pulses.

For marginally sustainable zones, watershed development remains the cornerstone intervention. Deshmukh's (2016) evaluation of the National Watershed Development Programme in Beed and Nanded demonstrated that comprehensive watershed treatment significantly improves groundwater recharge, agricultural productivity, and farmer incomes. Scaling up such programs with community participation—similar to the Saurashtra model documented by Patel et al. (2020)—offers proven pathways for enhancing sustainability.

For least sustainable zones, immediate policy attention is required to prevent humanitarian crises. Given the severe constraints on conventional agriculture, these zones require transformative approaches: promoting alternative livelihoods (livestock rearing, non-farm employment), guaranteed employment under MGNREGA for water harvesting, and, where necessary, facilitating out-migration with social safety nets.

### 5.2 Methodological Contributions:

This study contributes to the growing literature on geospatial MCDA for sustainability planning. The integration of environmental (groundwater, LULC, slope) and socio-economic (productivity, infrastructure) criteria within a coherent AHP framework provides a replicable methodology for regional sustainability assessment.

The specific criteria weights (groundwater potential: 0.301; proximity to surface water: 0.198; agricultural productivity: 0.187) reflect the empirical realities of semi-arid regions were water availability fundamentally conditions sustainability outcomes. This weighting scheme can serve as a template for similar assessments in drought-prone regions of India and beyond.

### 5.3 Limitations and Future Research Directions:

Several limitations of this study should be acknowledged. First, the reliance on district-level socio-economic data masks intra-district variations that may be significant for local planning. Higher-resolution data at tehsil or village level would improve accuracy. Second, the static nature of the analysis captures current sustainability status but does not incorporate temporal dynamics or climate change projections. Third, the exclusion of certain criteria—such as water quality, biodiversity, and social equity indicators—due to data constraints may have influenced the results.

Future research should focus on: (1) incorporating climate change scenarios to assess future sustainability trajectories, (2) developing dynamic sustainability models that capture feedback loops between environmental and socio-economic factors, (3) integrating high-resolution groundwater quality data, and (4) conducting village-level validation studies to ground-truth the sustainability zone classification.

## 6. Conclusion:

This research demonstrates the utility of geospatial multi-criteria decision analysis for identifying sustainable development zones in semi-arid regions, using Marathwada as a case study. The integration of remote sensing data with environmental and socio-economic criteria within an AHP framework has produced a spatially explicit sustainability assessment that can guide evidence-based policy making.

The findings reveal stark spatial disparities in sustainability across Marathwada. While 12.4% of the region exhibits high sustainability potential, nearly one-third (31.7%) falls under least sustainable zones requiring urgent policy attention. The concentration of least sustainable areas in Beed and Osmanabad districts reflects the compounding effects of hydrogeological constraints, drought vulnerability, and infrastructure deficits.

Geospatial technologies, as emphasized in recent literature, provide indispensable tools for understanding and addressing these complex sustainability challenges. By identifying priority zones for different types of interventions—efficiency enhancement in highly sustainable areas, infrastructure development in moderately sustainable areas, watershed rehabilitation in marginally sustainable areas, and livelihood transformation in least sustainable areas—this research offers a decision-support framework for regional planners.

Ultimately, achieving sustainable development in Marathwada requires moving beyond uniform policies toward spatially differentiated strategies that recognize the region's heterogeneity. The sustainability zone map developed in this study provides the scientific foundation for such targeted, evidence-based planning. As Marathwada confronts the twin challenges of climate change and agrarian distress, geospatial approaches to sustainability assessment will become increasingly essential for building resilient and equitable development pathways.

**References:**

1.Ghute, B.B., & Diwate, P. (Eds.). (2024). Geospatial Technologies for Integrated Water Resources Management: Mapping, Modelling, and Decision-Making. Springer.

2.Pawar, S.S. (2024). A Geographical Study of General Land Use Pattern in Marathwada Region. International Journal of Advanced Research in Science, Communication and Technology. https://doi.org/10.48175/ijarsct-19075

3.Unlocking sustainability potential: A SAFA framework analysis of sugarcane agriculture in Marathwada, Maharashtra, India. (2025). Sustainable Futures, 10, 101118.

4.Drought risk assessment and prediction using artificial intelligence over the Marathwada and Vidarbha Region, Maharashtra. (2024). In Ghute & Diwate (Eds.), Geospatial Technologies for Integrated Water Resources Management. Springer.

5.Bansode, P.S., & Nimbalkar, S.S. (2013). Study of land use pattern and cropping pattern of marginal farmers of Marathwada region of Maharashtra. Agriculture Update, 8(3), 440-442.

6.Patel, P.M., Saha, D., & Shah, T. (2020). Sustainability of groundwater through community-driven distributed recharge: an analysis of arguments for water scarce regions of semi-arid India. Journal of Hydrology: Regional Studies, 29, 100680.

7.Ghute, B.B., & Diwate, P. (2024). Drought risk assessment and prediction using artificial intelligence over the Marathwada and Vidarbha Region, Maharashtra. In Geospatial Technologies for Integrated Water Resources Management. Springer.

8.Jadhav, O.W. (2023). Agricultural Land Use Efficiency of Latur and Nilanga Taluka of Latur District. International Journal of Scientific Research and Management, 5(7).

9.Deshmukh, K.U. (2016). Impact of national watershed development programme on its beneficiaries in Marathwada region (Ph.D. thesis). Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani.

10.Ghute, B.B., & Diwate, P. (Eds.). (2024). Drought risk assessment and prediction using artificial intelligence over the Marathwada and Vidarbha Region, Maharashtra. In Geospatial Technologies for Integrated Water Resources Management. Springer.

11.Central Ground Water Board. (2024). Groundwater Yearbook of Maharashtra. Ministry of Water Resources, Government of India.

12.India Meteorological Department. (2024). District-wise Rainfall Data for Maharashtra. Pune: IMD.

13.National Remote Sensing Centre. (2024). *Land Use/Land Cover Mapping at 1:50,000 Scale*. Hyderabad: NRSC, ISRO.

14.NBSS&LUP. (2020). Soil Resource Atlas of Maharashtra. Nagpur: National Bureau of Soil Survey and Land Use Planning.

15.Census of India. (2011). District Census Handbooks: Aurangabad, Jalna, Beed, Parbhani, Hingoli, Nanded, Latur, Osmanabad. Government of India.

16.Department of Agriculture, Maharashtra. (2024). Agricultural Statistics at a Glance: Marathwada Region. Pune: Commissionerate of Agriculture.

17.Singh, J., & Dhillon, S.S. (2004). Agricultural Geography (3rd ed.). Tata McGraw-Hill.

18.Saaty, T.L. (1980). The Analytic Hierarchy Process. McGraw-Hill.

19.Malczewski, J. (1999). GIS and Multicriteria Decision Analysis. John Wiley & Sons.

20.Shinde, S.D., & Gaikwad, S.B. (2022). Geospatial analysis of groundwater potential zones in semi-arid region of Maharashtra using remote sensing and GIS techniques. Journal of the Indian Society of Remote Sensing, 50(3), 521-535.

21.Patil, V.T., & Kale, V.S. (2021). Assessment of agricultural sustainability in drought-prone areas of Maharashtra: A composite indicator approach. Current Science, 120(8), 1325-1334.

22.World Commission on Environment and Development. (1987). Our Common Future (Brundtland Report). Oxford University Press.

23.Gore, P.G., & Prabhakar, A.K. (2023). Climate change impacts on water resources in semi-arid regions of India: A review. Journal of Water and Climate Change, 14(2), 456-472.

24.Kulkarni, H., & Shah, M. (2022). Groundwater sustainability in western India: Lessons from Saurashtra and Marathwada. Economic and Political Weekly, 57(15), 45-53.

25.Deshpande, S.M., & Awasthi, M.K. (2021). Socio-economic determinants of farmer distress in Marathwada: A district-level analysis. Indian Journal of Agricultural Economics, 76(3), 389-402.

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# Green Chemistry: A Path to Sustainable Development - Principles, Methodologies, and Future Perspectives

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**ABSTRACT:**

Green chemistry, also known as sustainable chemistry, represents a transformative approach to chemical design, manufacturing, and application that seeks to eliminate or minimize the use and generation of hazardous substances. This research paper provides a comprehensive analysis of the fundamental principles, methodological innovations, and practical applications of green chemistry in advancing sustainable development goals. Originating from the environmental consciousness of the 1960s and formally established through the twelve principles articulated by Paul Anastas and John C. Warner in the 1990s, green chemistry has evolved into an interdisciplinary field spanning pharmaceuticals, materials science, energy production, and environmental remediation. This paper examines key methodological innovations including green solvents, biocatalysis, flow chemistry, microwave-assisted synthesis, and photocatalysis. It explores industrial applications across pharmaceutical synthesis, cosmetics manufacturing, and biorefinery operations, with particular emphasis on waste valorization and circular economy principles. The integration of green chemistry metrics and life cycle assessment tools is analyzed as essential for measuring sustainability performance. Finally, the paper discusses challenges in scalability, regulatory alignment with frameworks such as the Global Framework on Chemicals, and future research directions including artificial photosynthesis, digital twin optimization, and the development of comprehensive sustainability indicators. The findings demonstrate that widespread adoption of green chemistry principles is essential for achieving economic sustainability, regulatory compliance, and scientific innovation in the transition toward a more sustainable future.

Keywords: Green chemistry, sustainable development, twelve principles, biocatalysis, green solvents, circular economy, pharmaceutical synthesis, metrics, life cycle assessment

## 1. Introduction:

The chemical industry stands as a cornerstone of the global economy, producing hundreds of thousands of products essential to modern life—from pharmaceuticals and fertilizers to plastics, paints, electronics, cleaning products, and toiletries. However, this indispensable sector carries a significant environmental burden. The chemical industry is responsible for approximately 6% of global carbon emissions, primarily due to its heavy reliance on fossil fuel feedstocks and energy-intensive processes. Moreover, emissions from resource extraction, production processes, unsustainable use patterns, and inadequate disposal of chemicals contribute substantially to planetary pollution.

The conceptual foundations of green chemistry emerged from the environmental activism of the 1960s, catalyzed by Rachel Carson's landmark work "Silent Spring," which drew public attention to the environmental and health impacts of synthetic chemicals. The formal discipline of green chemistry was established in the 1990s through the articulation of the twelve principles by Paul Anastas and John C. Warner, providing a systematic framework for redesigning chemical products and processes to reduce or eliminate hazardous substances.

Green chemistry is fundamentally defined as "the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances" . This definition encompasses the entire lifecycle of chemical products, from raw material selection and synthesis through formulation, production, packaging, use, and ultimate degradation or disposal. Unlike traditional approaches that focus on end-of-pipe pollution control, green chemistry embeds environmental considerations into the fundamental design of chemical processes.

The imperative for green chemistry is particularly acute in the pharmaceutical industry, where conventional synthesis methods typically generate 25-100 kilograms of waste per kilogram of active pharmaceutical ingredient (API) manufactured—substantially higher than most other industrial sectors. This waste legacy includes toxic solvents, heavy metal catalysts, and stoichiometric reagents that pose significant environmental and health risks. The integration of green chemistry principles in pharmaceutical synthesis enhances efficiency and safety while reducing waste, toxicity, and energy consumption.

Green chemistry also plays a vital role in advancing the United Nations Sustainable Development Goals (SDGs), particularly those addressing health, industry innovation, and environmental sustainability. The recently launched "Global Framework on Chemicals" (2023) provides a comprehensive international plan with twenty-eight targets addressing the lifecycle of chemicals, with indicators partially oriented toward the concept of sustainable chemistry.

This research paper aims to: (1) provide a comprehensive overview of green chemistry principles and their evolution; (2) examine key methodological innovations driving sustainable chemical synthesis; (3) analyze industrial applications across multiple sectors; (4) evaluate metrics and assessment tools for measuring sustainability performance; and (5) discuss challenges, opportunities, and future research directions for advancing green chemistry as a path to sustainable development.

## 2. Principles of Green Chemistry:

### 2.1 The Twelve Principles:

The twelve principles of green chemistry, formulated by Paul Anastas and John C. Warner in 1998, provide an operational framework for redesigning chemical products and processes based on a rational and systematic method for reducing or avoiding hazardous substances. These principles are:

1. Prevention: It is better to prevent waste than to treat or clean up waste after it is formed. This principle prioritizes process design that minimizes waste generation rather than managing waste after production.

2. Atom Economy: Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product. This metric, developed by Barry Trost, measures the efficiency of a reaction based on the percentage of reactants that become products.

3. Less Hazardous Chemical Syntheses: Synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.

4. Designing Safer Chemicals: Chemical products should be designed to preserve efficacy of function while reducing toxicity. This involves understanding molecular structure-toxicity relationships.

5. Safer Solvents and Auxiliaries: The use of auxiliary substances (e.g., solvents, separation agents) should be made unnecessary wherever possible and, when used, should be innocuous.

6. Design for Energy Efficiency: Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure whenever possible.

7. Use of Renewable Feedstocks: A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.

8. Reduce Derivatives: Unnecessary derivatization (blocking group, protection/deprotection, temporary modification of physical/chemical processes) should be minimized or avoided, if possible, because such steps require additional reagents and can generate waste.

9. Catalysis: Catalytic reagents (as selective as possible) are superior to stoichiometric reagents. Catalysts can be used in small amounts to accelerate reactions and can often be recovered and reused.

10. Design for Degradation: Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.

11. Real-time Analysis for Pollution Prevention: Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.

12. Inherently Safer Chemistry for Accident Prevention: Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.

These principles are not mutually exclusive but rather interconnected, intended to guide the transition from conventional chemical production to safer, cleaner, and more sustainable alternatives.

## 2.2 Historical Evolution and Conceptual Development:

The intellectual roots of green chemistry extend to the environmental movement of the 1960s, with Rachel Carson's "Silent Spring" (1962) exposing the ecological and health impacts of pesticides like DDT. This work catalyzed public awareness and regulatory action, leading to the establishment of the U.S. Environmental Protection Agency (EPA) in 1970 and the enactment of environmental legislation throughout the 1970s.

The formal conceptualization of green chemistry emerged in the 1990s through several parallel developments. The EPA's Office of Pollution Prevention and Toxics began promoting pollution prevention through alternative chemical synthesis. In 1991, the EPA launched the "Alternative Synthetic Pathways for Pollution Prevention" research program. The term "green chemistry" was coined, and in 1995, President Clinton established the Presidential Green Chemistry Challenge Awards, recognizing outstanding achievements in environmentally benign chemical synthesis.

The publication of "Green Chemistry: Theory and Practice" by Anastas and Warner in 1998 codified the twelve principles and established the theoretical framework for the discipline. Since then, green chemistry has expanded globally, with academic journals (including the RSC's "Green Chemistry"), international conferences, and educational programs advancing research and awareness.

In recent years, the scope of green chemistry has broadened from its initial focus on synthesis to encompass the entire lifecycle of chemicals, including raw material extraction, manufacturing, use, and end-of-life management. The concept of "sustainable chemistry" has emerged as an overarching framework that integrates green chemistry principles with broader considerations of social equity, economic viability, and environmental stewardship across complete value chains.

## 3. Methodological Innovations in Green Chemistry:

### 3.1 Green Solvents and Reaction Media:

Solvents typically constitute the largest mass component of chemical processes, and their selection critically influences environmental impact, safety, and process efficiency. Traditional solvents such as dichloromethane, benzene, and other volatile organic compounds (VOCs) pose significant health and environmental hazards. Green chemistry has spurred the development of environmentally friendly alternatives.

Water as Solvent: Water is the most inexpensive, non-toxic, and abundant solvent available. Historically underutilized in organic synthesis due to polarity limitations and poor solubility of non-polar compounds, advances in reaction engineering have enabled aqueous-phase reactions using surfactants or phase-transfer catalysts. Aqueous-phase synthesis has found increasing application in amide bond formation, cycloaddition, and enzymatic catalysis.

Supercritical Carbon Dioxide ($scCO_2$): Carbon dioxide becomes supercritical above its critical point (31.1°C and 73.8 bar), exhibiting both gas-like diffusivity and liquid-like solvation strength. $scCO_2$ is inert, non-toxic, non-flammable, and can be easily removed by depressurization, leaving no solvent residue. It has been effectively employed in hydrogenation, oxidation, polymerization reactions, and supercritical fluid extraction of active pharmaceutical ingredients.

Ionic Liquids (ILs): These are salts that are liquid below 100°C, composed entirely of ions. Their tunable physicochemical properties—including negligible vapor pressure, thermal stability, and versatile solvation capacity—make them attractive for green synthesis. ILs enable multi-step reactions, electrochemical transformations, and enzymatic processes with high efficiency and reduced waste.

Deep Eutectic Solvents (DESs): Concerns regarding IL toxicity, cost, and recyclability have prompted development of DESs as greener alternatives. Created by combining hydrogen bond donors and acceptors (e.g., choline chloride and urea), DESs form liquids with melting points below those of individual components. They are biodegradable, less toxic, and easily prepared, finding applications in nucleophilic substitution, oxidation, and biotransformation reactions.

### 3.2 Green Catalysis:

Catalysis is fundamental to reducing the environmental impact of chemical synthesis by enhancing reaction selectivity, lowering activation energy, and minimizing by-products. The shift from stoichiometric reagents to catalytic systems represents one of the most significant contributions of green chemistry.

Biocatalysis: Enzymes and whole-cell systems are particularly desirable due to their exceptional substrate specificity, mild reaction conditions (ambient temperature and pressure), and renewability. Enzyme-catalyzed synthesis has been successfully applied in chiral intermediate production, esterification, and amide synthesis with high enantioselectivity. Biocatalysis is increasingly integrated with other green technologies; for example, the VIVALDI project uses engineered yeasts to transform $CO_2$-derived molecules into organic acids including lactic, itaconic, succinic, and 3-hydroxypropionic acids.

Organocatalysis: Small organic molecules catalyze reactions without metals, eliminating concerns about heavy metal contamination in products. Organocatalysts are typically robust, inexpensive, and stable under aerobic conditions.

Heterogeneous Catalysis: Supported metal catalysts and immobilized enzymes facilitate catalyst recovery and reuse, reducing waste and improving process economics. Advances in catalyst design-including rational ligand selection and support optimization-enhance performance and selectivity.

Photocatalysis and Electrocatalysis: Light- and electricity-driven catalysis enable chemical transformations under mild conditions using renewable energy sources. Recent breakthroughs include the development of a "semi-artificial leaf" combining organic semiconductors with bacterial enzymes to convert sunlight, water, and carbon dioxide into formate without toxic components or unsustainable additives.

### 3.3 Energy-Efficient Synthesis Technologies:

Microwave-Assisted Synthesis: Microwave irradiation provides rapid, uniform heating that can dramatically reduce reaction times from hours to minutes while improving yields and selectivity. This technique enables solvent-free reactions, reduces energy consumption, and has been successfully applied in synthesis of N-heterocycles, metal-organic frameworks, and pharmaceutical intermediates.

Flow Chemistry: Continuous flow processing offers enhanced heat and mass transfer, improved safety for hazardous reactions, and facile scalability. Flow chemistry facilitates precise control over reaction parameters and enables integration of multiple steps without intermediate isolation.

Mechanochemical Methods: Grinding and milling techniques enable solvent-free synthesis through mechanical energy input. Mechanochemistry has proven effective for synthesizing supramolecular structures, metal-organic frameworks, covalent-organic frameworks, and pharmaceutical cocrystals while eliminating solvent waste.

Ultrasonic Innovation: Ultrasound irradiation generates cavitation bubbles whose collapse creates localized elevated temperatures and pressures, accelerating reactions and improving extraction efficiency. Ultrasonication enhances mass transfer, reduces reaction times, and enables gentler extraction conditions for sensitive compounds.

## 4. Industrial Applications and Case Studies:

### 4.1 Pharmaceutical Industry:

The pharmaceutical sector has emerged as a leader in green chemistry adoption, driven by regulatory pressure, economic incentives, and corporate sustainability commitments. Key applications include:

Biocatalysis in API Synthesis: Enzymatic processes have replaced traditional metal-catalyzed steps in manufacturing blockbuster drugs. For example, the synthesis of the diabetes drug sitagliptin was revolutionized by a biocatalytic process using an engineered transaminase, eliminating a high-pressure hydrogenation step and a heavy metal catalyst while improving yield and purity.

Continuous Manufacturing: Flow chemistry enables continuous API production with reduced solvent use, improved safety, and smaller equipment footprints. The U.S. FDA has actively promoted continuous manufacturing as a green innovation.

Solvent Selection Guides: Pharmaceutical companies have developed solvent selection guides ranking solvents by environmental, health, and safety criteria, driving substitution of hazardous solvents with greener alternatives.

### 4.2 Cosmetics and Personal Care:

The cosmetics industry benefits from green chemistry through development of biodegradable materials, renewable ingredients, and safer preservatives. Consumer demand for "clean" beauty products has accelerated adoption of green chemistry principles, including:

- Replacement of synthetic fragrances with naturally derived alternatives
- Development of biodegradable emulsifiers and thickeners
- Elimination of microplastics from exfoliating products
- Use of green extraction technologies for botanical ingredients

### 4.3 Biorefinery and Waste Valorization:

The concept of biorefineries—facilities that convert biomass into fuels, power, and chemicals—exemplifies green chemistry's circular economy vision.

OLin WASTE Project: This Horizon Europe initiative transforms olive mill waste (pomace, stones, and leaves) into sustainable bioplastics, biofertilizers, biopesticides, and bioenergy. The project creates a fully integrated, zero-emission biorefinery using green chemistry and microbial processes. A System Digital Twin—a virtual model of the biorefinery's waste treatment and energy flows—enables continuous optimization, improving efficiency while reducing costs and carbon footprint.

VIVALDI Project: Sixteen European partners collaborate to convert $CO_2$ emissions from bio-based industries into high-value organic acids using a hybrid electrochemical-biotechnological approach. $CO_2$ is first converted into simple molecules (formic acid, methanol), then transformed by engineered yeasts into organic acids essential for bio-based plastics, coatings, and sustainable packaging. The project has demonstrated proof-of-concept prototypes including bio-based plastic cutlery and animal feed additives derived from $CO_2$.

### 4.4 Emerging Technologies: Artificial Photosynthesis:

Researchers at the University of Cambridge have developed a "semi-artificial leaf" that combines organic semiconductors with bacterial enzymes to convert sunlight, water, and carbon dioxide into formate—a fuel that can drive further chemical transformations. This biohybrid device avoids toxic semiconductors, lasts longer than previous designs (over 24 hours continuous operation), and runs without unsustainable additives by using a simple bicarbonate solution like sparkling water. The technology represents a fundamental platform for producing green fuels and chemicals without fossil fuel dependence.

## 5. Metrics and Sustainability Assessment:

### 5.1 Green Chemistry Metrics:

Quantitative metrics are essential for measuring progress, comparing alternatives, and guiding process optimization.

Atom Economy: Calculated as (molecular weight of desired product / molecular weight of all reactants) × 100%, these metric measures theoretical efficiency at the molecular level.

E-factor (Environmental Factor): Defined as (total waste mass / product mass), the E-factor quantifies actual waste generation. The pharmaceutical industry's typical E-factors of 25-100 highlight the need for improvement.

Process Mass Intensity (PMI): Calculated as (total mass of materials used / product mass), PMI provides a comprehensive measure of resource efficiency. Major pharmaceutical companies have publicly committed to PMI reduction targets.

Carbon Footprint: Greenhouse gas emissions associated with chemical processes, increasingly integrated into sustainability assessments.

### 5.2 Multi-Dimensional Assessment Tools:

Traditional mono-dimensional metrics can lead to incorrect conclusions; comprehensive assessment requires multi-dimensional frameworks.

Green Score Tool: Developed for assessing active pharmaceutical ingredient processes, Green Score integrates classical metrics based on the twelve principles with carbon footprint and biodiversity impact assessments. The tool generates a "Green Card" - a one-page summary providing clear overview of process sustainability and highlighting improvement areas.

Multi-Criteria Assessment: Luescher and Gallou (2025) present a practical, systematic framework evaluating environmental sustainability of chemical transformations using available data and simulating missing data for fair comparisons. This approach has proven reliable against complex LCA methodologies in identifying environmental hotspots and guiding research priorities.

### 5.3 International Framework and Indicators:

The 2023 "Global Framework on Chemicals" establishes twenty-eight targets addressing the lifecycle of chemicals, with indicators needed to monitor progress. Recent research has developed twenty-three indicators based on internationally established understanding of sustainable chemistry, evaluated through criteria assessing target relevance and suitability, and validated with international experts across all six UN regions. These indicators are related to multiple SDGs due to the overarching concept of sustainable chemistry.

## 6. Challenges and Future Directions:

### 6.1 Scalability and Implementation Challenges:

Despite demonstrated laboratory successes, scaling green technologies to industrial production remains challenging. Key barriers include:

- Economic factors: Green alternatives may require capital investment without guaranteed short-term returns.
- Technical hurdles: Reactions optimized at milligram scale may behave differently at metric ton scale.
- Regulatory complexity: New processes require regulatory approval, particularly in pharmaceutical manufacturing.
- Supply chain considerations: Renewable feedstocks require reliable, sustainable sourcing.

### 6.2 Integration with Digital Technologies:

Digital transformation offers opportunities to accelerate green chemistry adoption:

- Digital Twins: Virtual models enabling simulation, optimization, and continuous improvement of biorefinery operations.
- Machine Learning: Accelerating catalyst discovery, predicting reaction outcomes, and optimizing process conditions.
- Real-time Monitoring: Advanced analytics enabling in-process control and pollution prevention.

### 6.3 Future Research Priorities:

Priority areas for future green chemistry research include:

1. Optimizing green synthetic techniques for broader substrate scope and improved efficiency
2. Addressing scalability challenges through engineering research and demonstration facilities
3. Fostering interdisciplinary collaboration across chemistry, biology, engineering, and data science
4. Developing next-generation metrics moving toward LCA-type analysis while maintaining practical usability
5. Advancing artificial photosynthesis for direct solar-driven chemical synthesis
6. Expanding the bioeconomy through integrated biorefineries and waste valorization
7. Designing for circularity creating materials designed for recovery and reuse

## 7. Conclusion:

Green chemistry has evolved from a conceptual framework into a practical discipline fundamentally reshaping chemical research, development, and manufacturing. The twelve principles articulated by Anastas and Warner provide enduring guidance for designing inherently safer, more efficient, and environmentally benign chemical processes. Methodological innovations—including green solvents, biocatalysis, flow chemistry, microwave synthesis, and photocatalysis—offer powerful tools for implementing these principles across diverse applications.

Industrial adoption demonstrates that green chemistry delivers multiple benefits: environmental protection through reduced waste and emissions; economic advantages through improved efficiency and reduced material costs; enhanced safety for workers and communities; and regulatory compliance with increasingly stringent environmental standards. Projects like VIVALDI and Olin WASTE illustrate the potential of green chemistry to transform waste streams into valuable resources, advancing circular economy objectives.

The integration of green chemistry with broader sustainability frameworks—including the UN Sustainable Development Goals and the Global Framework on Chemicals—positions the discipline as essential for addressing global challenges of pollution, climate change, and resource depletion. Robust metrics and assessment tools, evolving from simple indicators to multi-dimensional frameworks, enable evidence-based decision-making and continuous improvement.

Looking forward, realizing the full potential of green chemistry requires sustained commitment to research, education, and industrial implementation. Interdisciplinary collaboration, digital technology integration, and supportive policy frameworks will accelerate the transition toward a sustainable chemical enterprise. As Professor Erwin Reisner observes, "We've got to come up with ways to de-fossilise this important sector, which produces so many important products we all need. It's a huge opportunity if we can get it right" .

The path to sustainable development runs through the molecular transformations that produce the materials of modern life. Green chemistry lights that path, offering not merely incremental improvement but fundamental redesign of the relationship between chemical technology and the natural systems that sustain it.

**References:**

1.Kurul, F., Doruk, B., & Topkaya, S.N. (2025). Principles of green chemistry: building a sustainable future. Discover Chemistry, 2(1), 1-25. Springer.

2.European Commission, Directorate-General for Environment. (2025, October 24). From $CO_2$ to Cash: Turning pollution into the next generation of products. Europa.

3.Luescher, M.U., & Gallou, F. (2025). Interactions of multiple metrics and environmental indicators to assess processes, detect environmental hotspots, and guide future development. Green Chemistry, 25th Anniversary Collection. Royal Society of Chemistry.

4.Principles of green chemistry: building a sustainable future. (2025). Discover Chemistry, 2(1), 1-25.

5.University of Surrey. (2025, July 10). Surrey researchers to help turn Europe's olive mill waste into bioproducts and clean fuel. EurekAlert!

6.Green Score: A User-Friendly Tool for Assessing the Sustainability of Chemical Processes. (2025). ScienceDirect.

7.Patel, P., Patel, P., & Mulla, T. (2025). Green Chemistry Approaches in Pharmaceutical Synthesis. Asian Journal of Research in Chemistry, 18(6).

8.University of Cambridge, St John's College. (2025, October 14). Solar power lights the way to fossil-free chemical industry. St John's College News.

9.Metrics are the key: development of criteria and indicators for measuring sustainability in international chemicals management. (2025). RSC Sustainability, 3(10), 4724-4745.

10.Prasad, L. (Ed.). (2025). Green Chemistry: A Path to Sustainable Development. Elsevier.

11.Anastas, P.T., & Warner, J.C. (1998). Green Chemistry: Theory and Practice. Oxford University Press.

12.Trost, B.M. (1991). The atom economy—a search for synthetic efficiency. Science, 254(5037), 1471-1477.

13.Sheldon, R.A. (2017). The E factor 25 years on: the rise of green chemistry and sustainability. Green Chemistry, 19(1), 18-43.

14.Jiménez-González, C., et al. (2011). Key green chemistry research areas from a pharmaceutical manufacturers' perspective revisited. Green Chemistry, 13(8), 1905-1918.

15.Bryan, M.C., et al. (2011). Key green chemistry research areas from a pharmaceutical manufacturers' perspective. Green Chemistry, 13(8), 1905-1918.

16.Woodley, J.M. (2020). Accelerating the implementation of biocatalysis in industry. Applied Microbiology and Biotechnology, 104(21), 8985-8994.

17.Sheldon, R.A., & Woodley, J.M. (2018). Role of biocatalysis in sustainable chemistry. Chemical Reviews, 118(2), 801-838.

18.Jessop, P.G. (2011). Searching for green solvents. Green Chemistry, 13(6), 1391-1398.

19.Clarke, C.J., et al. (2018). Green and sustainable solvents in chemical processes. Chemical Reviews, 118(2), 747-800.

20.Kerton, F.M., & Marriott, R. (2013). Alternative Solvents for Green Chemistry (2nd ed.). Royal Society of Chemistry.

21.Polshettiwar, V., & Varma, R.S. (2010). Green chemistry by nano-catalysis. Green Chemistry, 12(5), 743-754.

22.Anastas, P.T., & Zimmerman, J.B. (2003). Design through the 12 principles of green engineering. Environmental Science & Technology, 37(5), 94A-101A.

23.Erythropel, H.C., et al. (2018). The Green ChemisTREE: 20 years after taking root with the 12 principles. Green Chemistry, 20(9), 1929-1961.

24.Constable, D.J.C., et al. (2007). Key green chemistry research areas—a perspective from pharmaceutical manufacturers. Green Chemistry, 9(5), 411-420.

25.Clark, J.H., et al. (2016). Green chemistry and the biorefinery: a partnership for a sustainable future. Green Chemistry, 18(14), 3914-3934.

# About Digambarrao Bindu ACS College, Bhokar, Nanded, MS, India

# ICASD - 2026


Digambarrao Bindu ACS College, Bhokar, was established in 1989 by the visionary founding father, freedom fighter, and social worker, Honorable Late Bhujangrao Patil Kinhalkar. The college was named in honor of his ideal colleague and senior freedom fighter, Late Digambarrao Bindu. Since its inception, the institution has operated with high ideals, playing a key role in spreading quality education in the rural and backward surroundings of Nanded district, Maharashtra. Under the able leadership of the present president, Honorable Dr. Madhavrao Patil Kinhalkar (Former Minister, Government of Maharashtra), the college has progressed considerably in infrastructure and academics. His administrative experience and developmental vision continue to inspire the entire college community.

The college envisions providing value-based education and generating human resources equipped with advanced skills. Its mission includes making students aware of career opportunities, refining their personalities with a positive approach, reaching out to eligible but deprived students, creating environmental and social awareness, and offering skill-based courses. In 2011-12, the college added the Science faculty to the existing Arts and Commerce faculties. It now runs a Post Graduate department in Commerce, along with a Buddha Study Centre, Nehru Study Centre, and Gandhi Study Centre. The college actively participates in co-curricular, extra-curricular, and sports activities, with well-equipped indoor and outdoor games facilities. The NSS department has consistently contributed to the service of the nation.

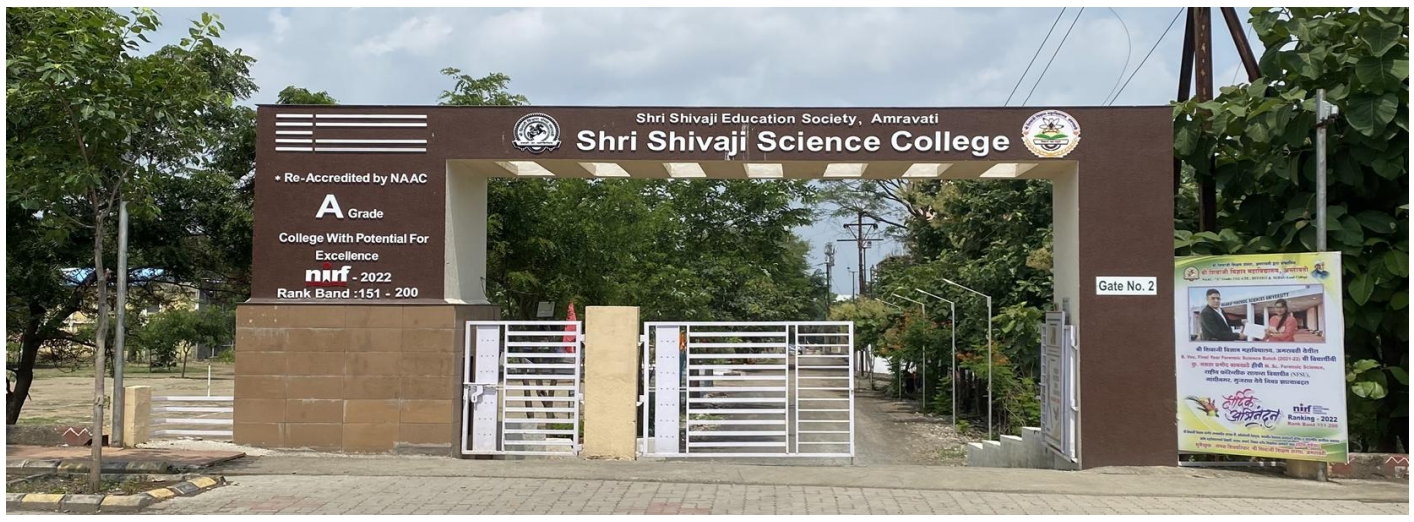
The college's commitment to quality has been recognized through numerous accolades. SRTMU, Nanded, has awarded the Best College Magazine Award to Vedan consecutively since 2009, along with the Best Examination Center Award in 2013-14. The Government of Maharashtra awarded a cash prize of two lakh rupees for NSS contributions to women empowerment under the Jagar Janivancha campaign in 2013-14. The college received Grade 'A' with 80.51 percentiles in the AAA Audit in 2020 and was re-accredited with 'B++' Grade (CGPA 2.87) by NAAC in 2023. The college has also been honored with the Best Principal Award (2017-18) and the Best College Award (2018-19) by SRTMU.

Research and quality enhancement are central to the college's ethos. Faculty have published 1378 research articles in reputed journals, along with 91 books, 187 edited books, and 252 book chapters. The college has received research grants and promotes intellectual property rights through workshops in collaboration with RGNIIPM, resulting in three patents and designs granted in 2023-24. The college has established three international, nine national, and seven local MOUs. The Science Club, founded in 2015 by Dr. Arvind Chavhan, fosters scientific interest through seminars, exhibitions, guest lectures, plantation drives, and National Science Day celebrations. The Country Wide Classroom Program (CWCP) by IQAC provides ICT classrooms, a YouTube channel (DBC Media Center), and Inflibnet e-library services. The Career Katta initiative offers career counseling, workshops, internships, and skill development programs. The NSS department has 175 volunteers engaging in community service with an annual seven-day camp in an adopted village. Through these endeavors, Digambarrao Bindu ACS College, Bhokar, continues to march strongly on the path of excellence.

Principal, Digambar Rao Bindu ACS College, Bhokar, Nanded, MS, India

# About Shri Shivaji Science College, Amravati, India

# ICASD - 2026




Shri Shivaji Science College, Amravati, is a flagship institution of the Shri Shivaji Education Society, one of Central India's largest and most prestigious educational organizations. Founded in 1932 by the legendary Dr. Panjabrao Deshmukh—India's first Agriculture Minister and a member of the Constitution Drafting Committee—the college carries forward a mission of empowering society through scientific temper and quality education.

What began as a specialized faculty in 1958 blossomed into an independent, premier science college in 1969. Over the decades, the institution has grown from a humble "seedling" into a towering "tree," providing shelter and world-class mentorship to thousands of students who now excel across the globe. Shri Shivaji Science College does not merely meet standards—it sets them. The college's commitment to academic rigor and institutional quality is validated by a string of prestigious national honors. It is proudly accredited with an 'A+' Grade (CGPA 3.42) in the Fourth Cycle by NAAC, alongside being conferred the elite CPE (College with Potential for Excellence) status by the UGC. The college's upward trajectory is most visible in the NIRF Rankings, where it has consistently climbed from the 151–200 rank band in 2022 and 2023 to breaking into the top tier at Rank 99 in 2024 and achieving a stellar Rank 93 in 2025.

The institution's infrastructure and research capabilities are fueled by powerhouse national grants, including the PM-USHA scheme for institutional strengthening, the DBT STAR College (Strengthening Component), and the prestigious DBT BUILDER and DST-FIST grants. Beyond its own walls, the college serves as a beacon for the region, recognized as a "Career Katta Centre of Excellence" by the Government of Maharashtra (2024) and nominated as a "Lead College" by Sant Gadge Baba Amravati University (SGBAU) to mentor and navigate other institutions toward quality enhancement. Furthermore, as a recognized NPTEL Local Chapter, the college bridges the gap between traditional learning and global digital certification, ensuring its students remain ahead of the curve.

Shri Shivaji Science College has moved beyond the classroom to create a high-octane environment where discovery meets entrepreneurship. The college empowers faculty through the Dr. Panjabrao Deshmukh Minor Research Grant, providing one lakh rupees per project to drive high-impact, interdisciplinary research. Its Ministry of Education-aligned Innovation Cell acts as a launchpad, transforming raw student concepts into tangible, market-ready prototypes with professional technical backing. Through PM-USHA and Career Katta, the Entrepreneurship Hub provides incubation and awards up to three lakh rupees in annual seed money to visionary undergraduate and postgraduate students.

The college campus is a model of sustainable excellence: lush and evergreen, powered by an automatic solar energy system. It houses a fully computerized library utilizing SOUL software, OPAC, and Inflibnet, alongside high-tech laboratories, smart classrooms, and campus-wide broadband connectivity managed by a highly competent, permanent faculty. Additional highlights include the Dr. Panjabrao Deshmukh Memorial Science and Innovation Activity Centre established with the support of RGSTC, as well as convenient accessibility from all parts of the state, spacious classrooms, modern laboratories, and excellent sports facilities. At Shri Shivaji Science College, the institution does not simply teach science—it inspires the innovators and entrepreneurs of tomorrow.

Principal, Shri Shivaji Science College, Amravati, India

About Acadivate Research and Innovation Foundation

# ICASD - 2026

ACADIVATE
An Architect of Academic Innovation

Slogan: Connecting Academia

Acadivate Research and Innovation Foundation is a non-profit organization dedicated to fostering sustainable development through research, innovation, and community empowerment. Established in 2024 with the vision of creating a more equitable and sustainable world, the foundation works at the vital intersection of academia, industry, and social development. Guided by its core belief in the power of knowledge, collaboration, and community engagement, Acadivate brings together experts, researchers, and change-makers to address pressing global challenges through evidence-based solutions and innovative approaches.

The foundation was founded with a clear view toward the extension of academic activities and the crucial task of connecting academia with global scientists and researchers to share knowledge and ideas among themselves for sustainability and the betterment of livelihoods. Acadivate actively fosters collaboration between universities and institutions within the country and overseas for research activities, ensuring that scientific advancements translate into tangible benefits for society, particularly for marginalized and vulnerable communities. Through its diverse initiatives, the foundation bridges the gap between research and practice, making academic excellence accessible and actionable.

A distinctive pillar of Acadivate's mission is its deep commitment to engaging individual students across the entire educational spectrum—from school children to PhD scholars. The foundation actively promotes science through vibrant science expos, well-established science clubs, and a wide range of activities designed to encourage students to explore, question, and innovate among themselves. These initiatives create a continuous pipeline of scientific curiosity and excellence, nurturing young minds at every stage of their academic journey.

Recognizing that true impact requires reaching the most underserved communities, Acadivate extends its efforts into the interiors of rural India. The foundation is dedicated to promoting science among those who do not have access to global development or remain unaware of current advancements due to the unavailability of resources required for connecting with global developments. By organizing mobile science exhibitions, rural science clubs, mentorship programs, and hands-on workshops in remote villages, Acadivate strives to democratize knowledge and ensure that no aspiring learner is left behind due to geographical or economic barriers. The foundation believes that talent is universal, but opportunity is not—and it works tirelessly to bridge that gap.

Acadivate takes pride in organizing seamless domestic and international symposia, conferences, seminars, and workshops. Among its flagship events is the International Conference on Advancing Sustainable Development (ICASD), which has successfully seen editions in Thailand (2024), Dubai (2025), and now Malaysia (2026). The foundation also recognizes and celebrates excellence through prestigious award ceremonies, encouraging delegates and researchers to strive for impactful contributions. With a growing global footprint and a steadfast commitment to collaboration, inclusion, and rural empowerment, Acadivate Research and Innovation Foundation continues to empower communities, inspire innovation, and shape a sustainable future for all.

President, Acadivate research and innovation Foundation.

## About Manipal University College Malaysia

# ICASD - 2026

Manipal University College Malaysia (MUCM) is a premier higher education institution located in the historical city of Melaka, Malaysia. Established over 28 years ago, Manipal University College Malaysia (MUCM) is dedicated to excellence in health sciences education.

Our university college offers a range of programs, including ..

- ✓ Foundation in Science.
- ✓ Bachelor of Medicine & Bachelor of Surgery (MBBS),
- ✓ Bachelor of Dental Surgery (BDS).
- ✓ Bachelor of Science (Honours) in Occupational Therapy (BOT).
- ✓ Bachelor of Science (Honours) in Physiotherapy (BPT).
- ✓ Bachelor of Science (Honours) in Psychology (BSc Psy).
- ✓ Master programme in faculty of medicine and dentistry.
- ✓ Many Short & Professional Courses.

Manipal University College Malaysia (MUCM) is known for its world-class faculty, modern laboratories, and extensive clinical training opportunities. The college has produced over 10,000 graduates who have significantly contributed to the Malaysian healthcare sector. Located just an hour from Kuala Lumpur International Airport, Manipal University College Malaysia (MUCM) provides easy accessibility for students.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College, Amravati, India