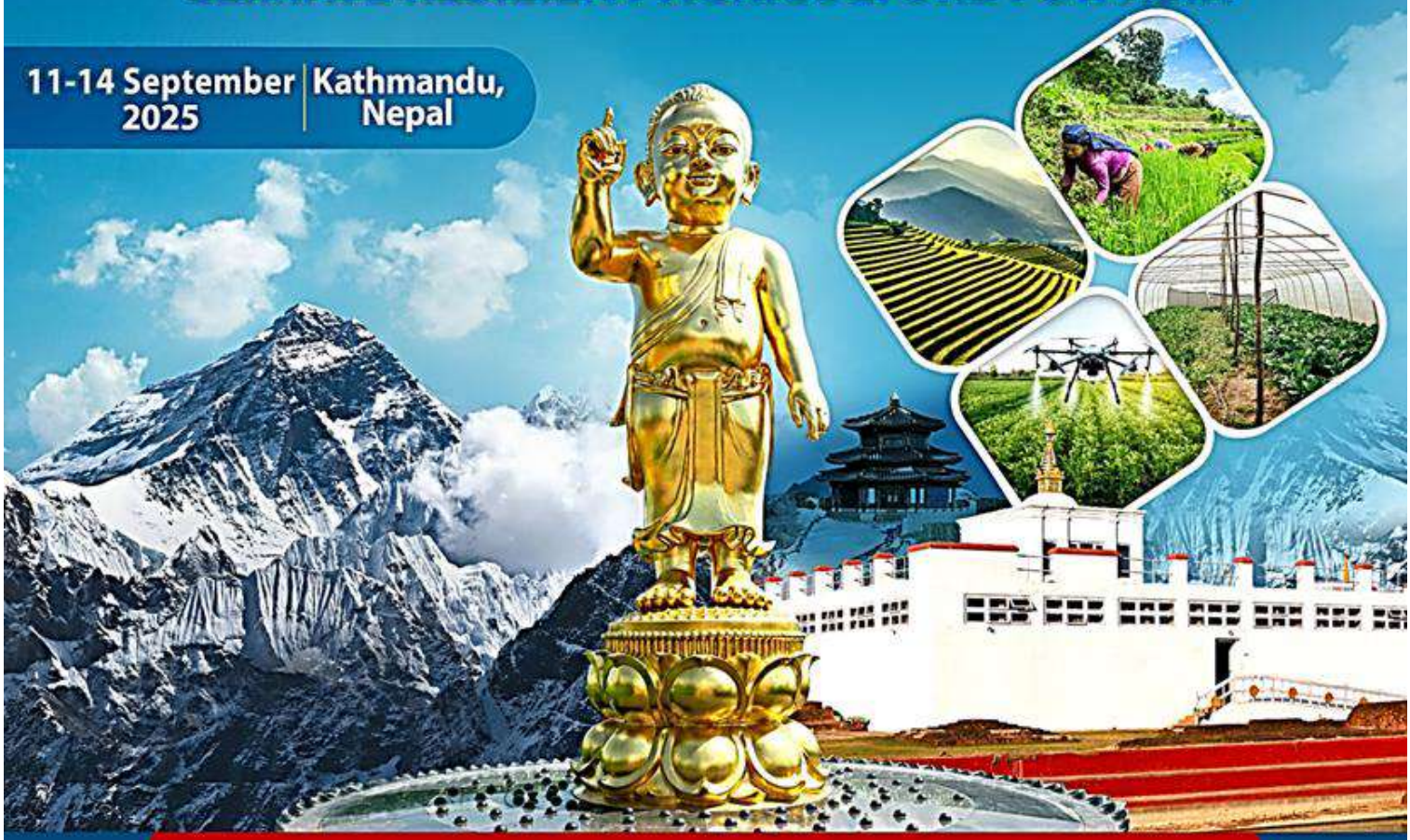
INTERNATIONAL AGRICULTURAL ENGINEERING CONFERENCE 2025

on

"CLIMATE RESILIENT AGRICULTURE FOR ASIA"

11-14 September 2025 | **Kathmandu, Nepal**



'COMPENDIUM OF ABSTRACTS AND SOUVENIR'

Hosted by | Napalese Society of Agricultural Engineers

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Indian Society of Agricultural Engineers

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AAAE International Conference 2025 & The 18th TSAE International Conference

September 11 – 14, 2025, Kathmandu, Nepal.

Climate Resilient Agriculture for Asia

The Asian Association for Agricultural Engineering (AAAE) in collaboration with Nepalese Society of Agricultural Engineers (NSAE), Thai Society of Agricultural Engineering (TSAE) and Indian Society of Agricultural Engineers (ISAE) holds the IAEC2025 during September 11-14, 2025 in the beautiful country of Nepal. The Conference will serve as a forum for dissemination and exchange of ideas and recent advances in agricultural engineering and related areas among students, academic researchers, industry personnel and interested participants, with the aim to bring the research results into practice for future.

Hosted by	Napalese Society of Agricultural Engineers
Co-Host	Kathmandu University, Dulikhel, Nepal
Organizers	Asian Association for Agricultural Engineering
	Thai Society of Agricultural Engineering
	Indian Society of Agricultural Engineers

AAAE Conferences

- International Agricultural Engineering Conference - AIT, Bangkok, December 7-10, 1992.
- International Agricultural Engineering Conference - AIT, Bangkok, from 6 – 9 December 1994.
- International Agricultural Engineering Conference, Pune, India, December 1996.
- International Agricultural Engineering Conference, 7-10 December 1998, AIT, Bangkok.
- International Agricultural Engineering Conference, AIT, Bangkok, 4-7 Dec. 2000.
- International Agricultural Engineering Conference, 28-30 November 2002, Wuxi, China.
- International Agricultural Engineering Conference, 6-9 November 2005, Bangkok, Thailand.
- International Agricultural Engineering Conference, Bangkok, 3-6 December 2007.
- International Agricultural Engineering Conference, Bangkok, 6-9 December 2009.
- International Agricultural Engineering Conference, 16-19 September 2014 (in conjunction with CIGR World Congress), Beijing, China
- AAAE International Symposium on 2-3 Oct 2023 at Aurangabad, India
- AAAE International Agricultural Engineering Conference (IAEC2025) at BITEC Bangkok during 22-24 May 2024 together with TSAE 17th International Conference

AAAE International Conference 2025 & The 18th TSAE International Conference

September 11 – 14, 2025, Kathmandu, Nepal.

'**Asian Association for Agricultural Engineering** (AAAE)' was founded on 5 Dec 1990 at Bangkok (Thailand), during an International Agricultural Engineering Conference at the Asian Institute of Technology (AIT**). International Agricultural Engineering Journal IISSN:0858-2114** (print) is being published from the Beijing office of AAAE The association AAAE is also a member of 'CIGR' – International Commission of Agricultural and Biosystems Engineering. In December 2022, AAAE was registered in India (Dist. Thane 401 206, Maharashtra).

AAAE Objectives

- To strengthen the profession of Agricultural Engineering by promoting information exchange, improving communications, minimizing duplication of activities, and optimizing use of resources.
- To formulate, establish, and promote voluntary academic, professional and technical standards of relevance to the profession of Agricultural Engineering in Asia.
- To support, at the international level, the activities of National Agricultural Engineering societies or related associations and to maintain liaison among them.
- To coordinate and assist in organizing timely international meetings in cooperation with national societies/associations within Asian region.

Executive Committee

URL: https://aaaesociety.org Email: office@aaaesociety.org

AAAE International Conference 2025 & The 18th TSAE International Conference

September 11 – 14, 2025, Kathmandu, Nepal.

Message from Gajendra Singh, Founding President of AAAE

The Asian Institute of Technology (AIT) established a new Division of Agricultural & Food Engineering in 1977 and organized an International Conference on “Rural Development Technology: An Integrated Approach” in June 1977. A good number of agricultural engineers attended the conference. Encouraged by its success, an International Conference on Agricultural Engineering was organized in November 1981. During this conference the idea of creating a regional association for agricultural engineering professionals was mooted.

With concerted efforts of agricultural engineers at AIT, the Asian Association for Agricultural Engineering (AAAE) was formed on December 5, 1990, by the participants of the International Conference on Agricultural Engineering held at AIT. Many participants became Foundation Members of AAAE. AAAE grew quite rapidly and organized the International Agricultural Engineering Conference (IAEC) biannually regularly. AAAE published an International Agricultural Engineering Journal (IAEJ) and a Newsletter regularly. In 2010 AAAE Secretariat moved to Chinese Academy of Agricultural Mechanization Sciences (CAAMS), Beijing. AAAE team in China did an excellent job, specially making IAEJ a highly reputed journal. During Covid-19 AAAE functioning became highly affected. In 2022, AAAE moved to India and registered as a Society. In 2023, a very successful International Symposium was organized at Aurangabad, Maharashtra with participants (including international) from industry, academia and government.

During developing the Strategic Plan, it was agreed to expand the activities and scope of AAAE truly as a regional association for professionals engaged in agricultural engineering activities, by making it a Consortium of societies/associations. In 2023, Thai Society of Agricultural Engineering (TSAE) and Agricultural Machinery Manufacturers Association (AMMA-India) joined as Consortium members. In 2024, TSAE with AAAE and AMMA-India, organized a highly successful international conference (IAEC2024) at Bangkok. During 2024, Indian Society of Agricultural Engineers (ISAE) and Nepalese Society of Agricultural Engineers (NSAE), joined AAAE as its Consortium members. With the efforts of AAAE members and members of the Consortium societies, other national societies/associations will soon join the AAAE as its Consortium member.

NSAE team, with support from AAAE and TSAE members, has been working extremely hard to make IAEC2025, a very successful and memorable event. I wish everyone a very pleasant stay, making new friends and reuniting with old friends and buddies.

AAAE International Conference 2025 & The 18th TSAE International Conference

September 11 – 14, 2025, Kathmandu, Nepal.

VASANTRAO NAIK MARATHWADA KRISHI VIDYAPEETH
Parbhani – 431 402 (Maharashtra) INDIA

Prof. Indra Mani
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President's Message

It gives me immense pleasure to welcome you all to the *International Agricultural Engineering Conference (IAEC-2025)* on *"Climate Resilient Agriculture for Asia"*, being organized by the Asian Association for Agricultural Engineering (AAAE) in collaboration with the Nepalese Society of Agricultural Engineers (NSAE) and the Thai Society of Agricultural Engineering (TSAE). The event is being graciously hosted by NSAE at Kathmandu University, Dhulikhel, Nepal. I express my gratitude to the Hon'ble Vice-Chancellor of Kathmandu University for providing assistance and facilities to organize this important event.

Agriculture in Asia is undergoing a profound transformation in response to climate change, which continues to challenge our pursuit of sustainable food production, environmental conservation, and improved livelihoods for farmers. The increasing frequency of extreme weather events, unpredictable rainfall, soil degradation, and water scarcity necessitates innovative, science-based solutions and collaborative efforts. *Future agriculture is engineering agriculture. Engineers must know biology and biologists must know engineering.* Mechnization and automation have been one of the top 20th inventions of the 21st Century. In this context, climate-resilient technologies, smart mechanization, renewable energy, digital innovations, drone applications, and sustainable farming practices have become essential to ensure food and nutritional security for our growing population. Development needs collaborations, innovations, and commercialization. This platform ensures collaboration among Asian countries in developing technologies to cope with climate change situations. Maharashtra's recent initiatives, such as the MahaAgri AI Policy for promoting AI-driven smart farming and the Mahavistaar App for delivering real-time advisories, schemes, and technology access to farmers, serve as promising examples of technology-led agricultural transformation.

The IAEC-2025 offers a unique platform for researchers, industry leaders, policymakers, and practitioners across Asia to share knowledge, showcase innovations, and deliberate on strategies to strengthen resilience in agricultural systems. I am confident that the discussions during this conference will lead to the development of scalable, affordable, and farmer-centric technologies that can be effectively implemented across diverse agro-climatic regions.

I express my heartfelt gratitude to our consortia member societies - NSAE and TSAE and to all sponsors, collaborators, and contributors for their invaluable support in making this conference a reality. I also extend a warm welcome to all the delegates and encourage you to actively participate in the deliberations, technical sessions, and networking opportunities that IAEC-2025 offers.

Together, let us move forward in building a climate-smart and sustainable agricultural future for Asia.

(Indra Mani)
President, AAAE

AAAE International Conference 2025 & The 18th TSAE International Conference

September 11 – 14, 2025, Kathmandu, Nepal.

INDIAN COUNCIL OF AGRICULTURAL RESEARCH (ICAR) Room No. 408, Krishi Anusandhan Bhavan-II, Pusa, New Delhi-1 10012, India

Dr. S N Jha, ARS

FNAAS, FIE, FISAE, FDADSI, FJSPS Japan

Deputy Director General (Agricultural Engineering)

President, Indian Society of Agricultural Engineers

I am delighted to note that the Asian Association for Agricultural Engineering (AAAE), in collaboration with the Nepalese Society of Agricultural Engineers (NSAE) and the Thai Society of Agricultural Engineering (TSAE) is organizing the International Agricultural Engineering Conference — 2025 on Climate Resilient Agriculture for Asia, to be held at Kathmandu University, Nepal, from 11—14 September 2025.

This prestigious event will bring together participants from across Asia and beyond, representing academia, industry, government and other sectors. Experts will share insights and innovations in key areas such as Farm mechanization, Land and water engineering, Food processing, Renewable energy, Climate resilience, Emerging technologies including AI, machine learning, and drones. The conference will feature numerous keynote addresses and lead talks by distinguished professionals, fostering meaningful dialogue and collaboration.

As President of the Indian Society of Agricultural Engineers (ISAE), a proud consortium member of AAAE, I extend my heartfelt appreciation to NSAE and TSAE for their initiative and commitment in hosting this landmark event. This collaboration demonstrates the shared vision of Asian nations to advance climate-resilient agriculture and sustainable farming practices.

In light of the growing global population, the responsibility to enhance food and feed production, generate employment and ensure nutritional and water security has never been enough. The adoption of advanced farm machinery and the reduction of labor-intensive practices are critical to achieving these goals. Agricultural engineering forums across Asia are actively addressing these challenges and this consortium-driven conference is a evidence to our collective efforts.

I am confident that the presentations and deliberations during the conference will pave the way for impactful partnerships across academia, industry, Government and farming communities. I congratulate the organizers, host institution and all consortium members for their dedication in making this event a resounding success.

I extend my warm greetings and best wishes to all participants and organizers and look forward to the fruitful outcomes of this important event.

(S N Jha)

DDG (Engg.) and President, ISAE

AAAE International Conference 2025 & The 18th TSAE International Conference

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Message from the President of Thai Society of Agricultural Engineering (TSAE)

Co-organizer, International Agricultural Engineering Conference 2025

The theme "Climate Resilient Agriculture for Asia" could not be more timely or critical. As we face unprecedented climate challenges across the Asian continent, our collective expertise in agricultural engineering becomes essential for developing sustainable solutions that ensure food security for billions of people. Asia's diverse agricultural landscapes—from the rice terraces of Southeast Asia to the wheat fields of South Asia—require tailored engineering solutions that can withstand climate variability while maintaining productivity and sustainability.

As co-organizer of this conference, TSAE brings nearly five decades of experience in advancing agricultural engineering across Thailand and Southeast Asia. Founded in 1976 with the vision of "Enhancing Agriculture through Engineering Excellence," our society has served as a vital bridge between research institutions, industry practitioners, and agricultural communities. Our mission of "fostering innovation through collaboration between researchers, manufacturers, and end-users to advance agricultural technology nationwide" aligns perfectly with the goals of IAEC 2025.

Throughout our history, TSAE has contributed to Thailand's agricultural transformation from traditional farming to modern, technology-driven approaches. We are proud to be recognized as a Thai Industry Standard Institute (TISI) appointed Standards Developing Organization and Ministry of Finance registered Industrial consultant. Our international partnerships with DLG, AAAE, ACABE, CAMM, CSAM, and ReCAMA demonstrate our commitment to global collaboration in addressing agricultural challenges.

TSAE actively promotes research and development in precision agriculture, irrigation and water management, post-harvest technology, renewable energy in agriculture, agricultural machinery and automation, and climate-smart farming solutions. Our diverse membership of agricultural engineers, researchers, academics, students, and industry professionals shares a common commitment to advancing agricultural engineering sciences and applications.

Through IAEC 2025, we have the opportunity to bridge traditional agricultural wisdom with cutting-edge engineering innovations, fostering collaboration that transcends national boundaries. This conference provides an invaluable platform for sharing innovative technologies, research findings, and best practices that will shape the future of agriculture in our region.

I encourage all participants to engage actively in the technical sessions, poster presentations, and networking opportunities. The relationships formed and knowledge shared during these four days will undoubtedly contribute to developing climate-smart agricultural systems that benefit farmers, communities, and nations across Asia.

Together, let us work toward a future where agricultural engineering serves as the cornerstone of climate-resilient food systems, ensuring prosperity and sustainability for generations to come. Through partnerships like IAEC 2025, TSAE continues to contribute to the development of resilient agricultural systems that benefit farmers and communities throughout Asia.

Mrs. Dares Kittiyopas
President
Thai Society of Agricultural Engineering (TSAE)

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September 11 – 14, 2025, Kathmandu, Nepal.

Message from Dr Jeet Chand, President of NSAE

Nepalese Society of Agricultural Engineers (NSAE) was established in 1990 as a non-profit professional organization and fraternity of Agricultural Engineers in the country. The headquarter of NSAE is located in Harihar Bhawan, Lalitpur, Bagmati Province Nepal. There are around 700 active members in NSAE including 310 life members. The major mission of NSAE is to make agricultural engineering profession more effective and scientific and also to contribute government, private and non-government sector while formulating policies, program and projects related to agriculture and rural development sector. NSAE focuses on safeguarding of rights and interests of Nepalese agricultural engineers and thus promoting development of science and technology.

NSAE is conducting various activities since its establishment including Career prospect for prospective students on the course of study in Agricultural Engineering; conducting national and international seminar; setting and enforcing professional standards, advancing knowledge through publications and events, and supporting members' professional development through training, networking, and certification. NSAE also acts as advocates for agricultural engineering profession to the public, and some also work to promote diversity, equity, and inclusion within their fields. In addition, society equally influences other visible functions: to publish professional biodata, to develop professional excellence, to raise public awareness, and to make awards and recognition. In short, NSAE contributes to advance the agricultural engineering profession in Nepal, support the interests of people working in that profession and serve the public good. It facilitates innovation, communication and connection with multi-stakeholders in agriculture sector which is the backbone of national economy.

As the president of Nepalese Society of Agricultural Engineers (NSAE), I am pleased to write here - **Compendium of Abstracts,** published on the auspicious occasion of International Agricultural Engineering Conference, taking place on 11-14 September 2025 at Kathmandu University, Dhulikhel, Nepal. This **Compendium of Abstracts** primarily focuses on “Climate Resilient Agriculture for Asia” and offer opportunities as a forum for dissemination and exchange of ideas and recent advances in agricultural engineering and related areas. The book will contribute to connect government officials, academic researchers, scientists, industry personnel, students and interested persons, with the aim to bring the research results into practice for sustainable farming in Asia region.

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Message from the Chief Editor IAEJ

Greetings from the Asian Association for Agricultural Engineering (AAAE)!

On behalf of the AAAE Editorial Board, I want to express my heartfelt thanks and appreciation to all those who submitted their papers for publication and contributed to help us revive the International Agricultural Engineering Journal (IAEJ) published by AAAE. Without your trust in submitting your papers for publication in our journal, we would be able to achieve this goal. We are publishing the 2025 issue of the IAEJ after a lapse of five years with fourteen refereed journal articles. Each paper was reviewed by at least two expert reviewers and gone through extensive revisions by authors before papers are accepted for publication. The 2025 issue of the IAEJ is the result of hard work of authors by submitting their papers and dedication of members of the ***Editorial Board of IJAE*** for getting papers reviewed, revised and edited before being accepted for publication in this issue. Your unwavering support and commitment to ensuring the quality of our journal have been crucial to our success, and I am truly grateful for all of you.

Your expertise, insights, and suggestions have helped us to maintain high standards and meet the expectations of our readership. Your dedication and professionalism have inspired us to aim for excellence in publishing a quality journal. An effective between the editorial board members and your prompt response to our queries, and timely reviews of our manuscripts have been invaluable to us, and we could not have achieved our goals without your support. Your guidance, advice, and encouragement have made a significant difference in our work.

On behalf of the entire editorial team, I will encourage members of Thai Society of Agricultural Engineers, Nepalese Society of Agricultural Engineers, Indian Society of Agricultural Engineers and AAAE to consider submitting their scholarly work for publication in the IAEJ. This will truly help in making AAAE a leading professional organization in Asia and the world. I look forward to your contributions. Thank you once again for all that you have done for us as authors, members of the editorial board, AAAE headquarters staff and most importantly our readers. Your interest in AAAE, efforts, and contributions to the IAE are truly appreciated.

Thanks, and regards,

Rameshwar S. Kanwar

Chief Editor of IAEJ

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AAAE AWARDS 2025

Early Career Award

Dr. NRNV Gowripathi Rao

Mid-Career Award

Dr. Uday Manohar Khodke

Young Researcher Award

Dr. Rouf Ahmad Parray

Researcher of the Year

Dr. Srinivasulu Ale

ASPEE Young Indian Researcher Award

Dr. Madhuresh Dwivedi

Young Industry Leadership

Young Educator Award

Dr. Nickhil C.

Excellence in International Engagement

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สมาคมวิศวกรรมเกษตรแห่งประเทศไทย
THAI SOCIETY OF AGRICULTURAL ENGINEERING

TSAE Best Paper Awards

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Melanie Piedad, Carolyn Grace Somera, Małgorzata Korzeniowska, Wojciech Łaba, Joel Salazar, Melba Denson and Jeffrey Lavarias

ID26

"Design and Development of an AI-based LINE Chatbot for Detection and Identification of Major Chili Plant Diseases"

Thanakorn Promkhotka, Napat Thongsen, Pranot Maniin, Tanatya Kenkhunthot, Artit Pongtip, Banyat Saitthiti and Piyapong Sriwangras

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AAAE International Conference 2025 & The 18th TSAE International Conference

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IAEC 2025 – ACD - 01

Reengineering Agricultural Engineering Curriculum and Research in South Asia: Status, Issues & Recommendations

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Abstract

This Paper briefly reviews the timewise progress of India's higher agricultural educational system since independence in 1947, encompassing both public and private sectors. Paper identifies the challenges the agricultural education system faces and urgent need for its comprehensive reform in the agricultural engineering curriculum and restructuring so that it becomes capable of producing well-trained, skilled, knowledgeable, and globally competitive and passionate professionals to serve India's and South Asia's complex and diverse agricultural production systema. Agriculture in South Asia currently faces a range of challenges including its growth, farmers' incomes and climate resilience and sustainability. This would require India's agricultural universities and colleges to recruit best and brightest talented pool of faculty who are trained in these diverse technologies, allow the current faculty to retrain themselves with new technological advancements to and then prepare students with new knowledge on climate resilient and environmentally friendly farming systems as lifelong learners, entrepreneurs and practitioners.

The prevailing higher agricultural education system in India, which includes 74 public sector universities (SAUs) and several private universities and colleges, faces issues like other higher education universities and colleges in India. The 2020 National Education Policy (NEP 2020) documented these problems, including (a) rigidity in adopting multi-disciplinary educational programs; (b) limited presence of quality educational institutions in socio-economically disadvantaged areas; (c) almost zero teacher and institutional autonomy; (d) lack of merit-based faculty recruitment, inbreeding, and career development opportunities; (e) no encouragement for faculty research and the lack of reward system for faculty excellence; (f) poor governance of universities for excellence and national/international leadership in research, exacerbated by politically appointed vice-chancellors; (g) ineffective regulatory systems.

Therefore, this Paper takes an out-of-box approach to make concrete recommendations to move away from 100% state-run agricultural universities with poorly governed private-sector agricultural universities and colleges in India. India needs a constitutionally and operationally self-governed, autonomous yet accountable higher educational system. Non-performing institutions could be phased out over time rather than giving them a lifelong tenure of a non-performing institution producing mediocre or below average talent and bringing unnecessary financial and social burden on the society. Policies and criteria should be developed and implemented to reward SAU faculty for research productivity and create an inviting and competitive environment for research at SAUs. This will uplift India's agriculture into a knowledge driven economy and will help bring farmers out of poverty. In addition, India SAU will aspire to be ranked among the top 200 to 500 ranking universities in the World as per QS World University ranking criteria.

Keywords: *Agricultural Engineering Curriculum; Reengineering; South Asia; NEP.*

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Carbon-Neutral Meals: Another Step towards Sustainability

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Abstract

One of the United Nations' Sustainable Development Goals (SDGs) is Responsible Consumption and Production (Goal 12), which aims to decouple economic growth from environmental degradation through improved resource efficiency and promotion of sustainable lifestyles. The food sector, encompassing production, transportation and consumption, accounts for nearly 30% of global energy use and contributes around 22% of total greenhouse gas emissions. Addressing environmental impact of this sector is therefore a critical priority. Achieving carbon neutrality in foods or meals requires three key steps: (1) measurement and assessment to identify emission sources and quantify outputs; (2) reduction through practices such as modifying animal feeding, improving manure management, enhancing fertilizer and irrigation efficiency, utilizing seasonal, local and alternative raw materials, minimizing food loss and waste as well as adopting renewable energy; (3) offsetting or removing remaining carbon dioxide equivalents (CO_2-equivalent). For carbon neutrality to be realized, all CO_2-equivalent emissions generated during production, transport and consumption of foods must be fully balanced, so that no net increase in atmospheric CO_2-equivalent occurs. This presentation examines carbon footprints of different foods, discusses pathways toward low-carbon and carbon-neutral dietary choices and highlights technological innovations that can reduce emissions in the food sector. Emerging concepts such as carbon-neutral kitchens and restaurants are addressed, together with opportunities to upcycle food waste into novel food products. Finally, strategies for offsetting residual emissions, including afforestation, forest restoration and biomass production from food residues, are considered as viable approaches to advancing sustainability in the global food system.

Keywords: *Carbon footprint; Carbon-neutral kitchen; Composting food waste; Greenhouse gases; Menu from food waste; Sustainable food production.*

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Climate Resilient Technologies for Future Agriculture

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Abstract

Agriculture in Asia stands at a critical juncture as climate change increasingly threatens the stability of food systems, rural livelihoods, and natural resources. The region, home to nearly 60% of the world's population, is highly vulnerable to rising temperatures, erratic rainfall, droughts, floods, and extreme weather events. These challenges are particularly acute for small and marginal farmers who form the backbone of Asian agriculture. Addressing these concerns requires urgent adoption of climate-smart agriculture and climate-resilient technologies that can secure productivity while conserving natural resources and reducing vulnerability. Agriculture in Asia is therefore undergoing a profound transformation, with climate change compelling us to rethink sustainable food production, environmental conservation, and farmer livelihoods. The increasing frequency of extreme weather, soil degradation, and water scarcity necessitates innovative, science-based solutions and collaborative efforts. Future agriculture is engineering agriculture—engineers must know biology and biologists must know engineering. Mechnization and automation have been one of the top 20th inventions of the 21st Century. In this context, climate-resilient technologies, smart mechanization, renewable energy, digital innovations, drone applications, and sustainable farming practices have become essential to ensure food and nutritional security. The path forward must be shaped by collaborations, innovations, and commercialization to build a resilient agricultural future for Asia.

Climate-resilient agriculture emphasizes the development and deployment of adaptive technologies, sustainable farming practices, and integrated resource management. The approach includes drought tolerant crop varieties, water harvesting structures, renewable energy use, precision farming, mechanization and digitalization in farming. It also stresses diversification, conservation of soil and water, and risk management strategies. Such innovations are essential not only for ensuring food security in Asia but also for safeguarding farm incomes against climate shocks.

The Presentation shall cover the programs and institutional interventions by Indian council of Research (ICAR), NICRA and the world bank project PoCRA besides the initiatives taken by our university *Vasantrao Naik Marathwada Krishi Vidyapeeth* (VNMKV) Parbhani.

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IAEC 2025 - FMP - 01

Variable Rate Spraying System for Disease Control in Paddy Field Using Image Processing Technique

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Abstract

Agrochemicals are viewed as a cost-effective, labour-saving tool for disease control and crop growth. However, traditional agrochemical application, especially in smallholders' context, resulted in an excessive, injudicious, and ineffective method that raised disease control costs. This study developed a real-time, variable-rate agrochemical spraying system based on paddy leaf disease severity using image processing techniques with necessary open-access sensors to ensure precise chemical application. The study collected five paddy plants with different leaf disease levels of *BRRI dhan29* variety from on-farm paddy field that was placed in a container in lab condition, with a envision to implement this preliminary lab trial in on-farm smallholder arable farming context. The developed automated cart with variable-rate sprayer was positioned behind the line of plants and switched on, and moved systematically along the line of plants. The integrated camera on the cart captured images and stored them in the Raspberry Pi for further analysis. The study found 34% to 42% of the infected leaf area through image processing. The discharge volume was obtained on average with a standard deviation of 0.353±0.0031, 0.235±0.0032, and 0.097±0.0016 mL for 1, 0.6, and 0.2 s pump operation time, respectively. Results indicate that discharge volumes among pump operation times were significantly different from each other. The volume median diameter (VMD) was found at 1056, 1030, and 264 µm with number median diameter (NMD) at 111, 90, and 80 for 1, 0.6, and 0.2 s pump operation time, respectively. The homogeneity factor was obtained at 9.46, 11.43, and 3.3 for 1, 0.6, and 0.2 s pump operation time, respectively. This indicates that the 0.2 s pump operation produces more uniform droplet sizes than 1 and 0.6 s operations during spraying of agrochemicals.

Keywords: *Disease Control; Spraying; Paddy; Image Processing; Microcontroller.*

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IAEC 2025 – FMP – 02

Development and Performance Assessment of Hydroponic Mat-Type Seedlings for Mechanical Rice Transplanting

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Abstract

Rice production in Bangladesh faces challenges in ensuring high-quality seedlings for efficient mechanical transplanting. This study developed a hydroponic mat-type seedling-raising system and evaluated its suitability for mechanical transplanting using BRRI dhan103, a 126-day rice variety. The experiment was conducted during the T. Aman season (July–November 2024) at BRRI Farm, Gazipur, with a randomized complete block design with three plant spacing, *viz.,* 30 cm × 25 cm, 30 cm × 20 cm and 30 cm × 15 cm. Seed rate of 180g across 100 trays were used. Seedlings reached an average height of 12.26 cm in 7 days, achieving a density of 56 seedlings per 16 cm². Mechanical transplanting resulted in 10.8% missing hills, 8.8% mechanically damaged hills, 3.32% buried hills, and 4% floating hills, ensuring effective hill establishment with an average transplanting depth of 4.80 cm. Plant height averaged 22.16 cm, 73.66 cm, 117.5 cm, and 138.83 cm at 15, 30, 45, and 60 days, respectively. Tiller counts reached 18.66 per hill by day 60, with 15.66 effective tillers/hill. Panicle length was 26.66 cm with 203.16 filled grains/panicle and minimal unfilled grains (27.33). The 1000-grain weight of 23.33 g contributed to an average grain yield of 5.93 t/ha, along with straw yield (5.63 t/ha), biological yield (12.2 t/ha), and a harvest index of 53.5%, particularly for S2 spacing, which outperformed other spacing. Economic analysis revealed production costs of 41,031–62,067 BDT/ha, gross returns of 55,659–84,879 BDT/ha, production costs of 13.88–19.30 BDT/kg, and a benefit-cost ratio (BCR) of 1.21–1.57. This eco-friendly system, eliminating soil use and reducing risks from early floods and hailstorms, ensures robust seedling establishment. It demonstrates the potential to enhance rice productivity and mechanical transplanting suitability, promoting sustainable rice cultivation in Bangladesh.

Keywords: *Hydroponic; Seedling; Growth; Yield; Cost; Return.*

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AI-IoT Enabled Jute Fibre Grading System

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Abstract

Grading of jute fiber is crucial for determining the quality and price of the final product. In India, the common method of grading is the hand-and-eye approach, which is subjective and lacks a scientific foundation. The current instrumental method for jute grading is time-consuming, tedious, and prone to human error. Therefore, an integrated instrument capable of measuring all the physical parameters of jute is necessary to expedite grading and provide accurate results. The developed AI-IoT enabled jute fibre grading instrument consists of a sample tray, feed roller, conveyor, image capturing unit, color measurement unit, and bundle strength unit. The conveyor moves the fibre at a fixed distance under the image capturing unit, which uses Raspberry Pi camera with a rolling shutter, captures images as the fibre passes under it. The bundle strength measurement unit features a fibre breaking unit with a limit switch, motors, an S-type load cell with an amplifier, and an Arduino microcontroller. This unit employs three motors: one to exert a constant loading rate through the jaw base, and the other two to facilitate the jaw's to-and-fro motion. Among the five physical parameters of jute fiber, three are measured using an Artificial Intelligence models, while two are measured using sensor-based technology. For the machine learning model, approximately 4000 datasets were created, with 2000 used to test the model. The instrument can test fibers within five minutes with an accuracy of 90%, outperforming traditional grading methods. The same instrument can be used for grading of *mesta* and *bimli* also.

Keywords: *AI; IoT; Cloud Server; Jute Fibre Strength.*

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Impact of Transformation from Rice Land into Fish Farming in Some Selected Areas in Mymensingh District

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Abstract

This study explores the economic implications of transforming rice farmland into fish farming in Mymensingh district, Bangladesh, where land scarcity and declining rice profitability are driving land-use changes. A total of 120 farmers were selected with 60 fully transformed (fish-only) and 60 partially transformed (fish and rice) from Tarakanda and Phulpur Upazilas, based on high concentrations of aquaculture adoption. Data were collected through structured, pre-tested interviews conducted from April to June 2022, covering a six-month cycle of Boro rice and mixed fish culture. Analytical tools included cost-return analysis, benefit-cost ratio (BCR), Gini coefficient, Lorenz curves, and paired t-tests. Results showed that fully transformed fish farmers had higher average total costs (476,044 BDT) but significantly higher gross returns (1,005,000 BDT) and net returns (528,956 BDT), with a BCR of 2.11. In contrast, partially transformed fish farmers earned a net return of 329,161 BDT with a BCR of 1.85, while partially transformed rice farmers earned only 17,518 BDT with a BCR of 1.12. Gross margin for fully transformed fish farmers was 623,956 BDT; 52% higher than that of partially transformed fish farmers. Income inequality was more pronounced among fully transformed farmers (Gini coefficient = 0.43) than partially transformed ones (0.35), indicating disproportionate benefits within the group. A paired t-test confirmed a statistically significant difference in net returns between the groups ($p = 0.003$). Key drivers for transformation included higher profits (93%), labor shortages (80%), and high input costs in rice farming (78%). However, farmers faced critical challenges such as high feed costs (87%), poor-quality fingerlings (67%), and limited technical knowledge (58%). The study recommends enhanced institutional support, access to quality inputs, farmer training, and market development to sustain profitable and equitable aquaculture expansion in rural Bangladesh.

Keywords: *Cost; Farming; Fish; Fully and Partially Transformed Return; Income; Rice.*

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Paper No.: IAEC 2025- FMP-05

Machine Vision Approach in Identification of Paddy Varieties

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Abstract

Distinguishing paddy varieties according to external traits is a crucial matter in image processing. The study presents an algorithm applied to determine paddy variety. Physical trait detection combining with size, shape and eccentricity, the machine vision approach was applied to develop model using artificial neural network in MATLAB 2015 software to determine and distinguish paddy varieties. Developed machine vision algorithm was able to detect paddy variety analyzing image of it to real time observation. In the first step, a simple size sorting based on mathematical binarization is described, and the second step is to segment the eccentrics; to do this, color based classifiers are used. The developed machine vision approach can measure paddy variety with a good level of reliability compared to human vision. About 75% data from dataset of paddy variety individually of BRRI Dhan28, BRRI Dhan29, and BRRI Dhan81 were trained to develop machine vision algorithm, then rest 25% data were tested through that. It revealed that the variety is BRRI Dhan28, BRRI Dhan29, and BRRI Dhan81, respectively. Three different images from each of the classes were tested and found accurate for particular variety identification. The approach can be integrated with paddy sorting, defect detection of paddy, and purity test of paddy seed. Color of paddy can be taken as the feature of further study. It will increase the efficiency and accuracy of the developed machine vision system.

Keywords: *Identification; Image; Paddy; Processing.*

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Detection of Weeds Using UAV Multispectral Imaging and Machine Learning

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Abstract

Timely and accurate weed detection is essential in precision agriculture, particularly for crops like groundnut, where spectral overlap between weeds and crops can significantly impact yield. Manual weed control methods are labour-intensive, time-consuming, and lack scalability. This study investigates an automated, scalable weed detection approach using UAV-based multispectral imaging and machine learning techniques. Data were collected for 60 days after sowing from a groundnut field at Agricultural Extension Education Centre (AEEC), Lingsugur, Karnataka, using a RedEdge-MX multispectral camera mounted on a UAV at altitudes of 30 m, 40 m, and 50 m. Five spectral bands - blue, green, red, red edge, and near- infrared were captured and processed in Google Colab using a fully code-based pipeline. A ground truth dataset was generated *via* automated class labelling (bare land = 0, crop = 1, weed = 2), followed by image correction, band stacking, and normalization to form structured datasets. Several supervised classifiers - Convolution Neural Networks (CNN), Artificial Neural Networks (ANN), Random Forests (RF), and Support Vector Machines (SVM) - were trained and evaluated using pixel-wise classification, confusion matrices, and spatial overlays. CNN outperformed other models with an accuracy of 96.88%, effectively capturing complex spatial-spectral patterns. ANN followed with 94.32%, while SVM and RF achieved 79.46% and 71.73%, respectively. K-Means was excluded due to its unsupervised nature. The study demonstrates the effectiveness of combining low-cost UAVs, open-source tools, and deep learning for high-precision weed detection. The resulting prediction maps and GIS-ready outputs provide valuable support for informed, scalable weed management in groundnut cultivation.

Keywords: *Machine Learning; Multispectral Imaging; Precision Agriculture*; *UAV; Weed Detection.*

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Paper No.: IAEC 2025- FMP-07

Mechanization Dynamics of Paddy Cultivation in Chhattisgarh

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Abstract

Paddy cultivation in Chhattisgarh covers around 3.7 million hectares, which constitutes over 70% of the state's cultivated area. In recent years, agricultural mechanization has become increasingly significant in improving operational efficiency, energy utilization, and labor productivity across the state's diverse agro-climatic zones. This study examines the mechanization dynamics of paddy cultivation in Chhattisgarh Plains, Bastar Plateau, and the Northern Hills of Sarguja, focusing on machinery adoption trends, energy footprints, and farm-level performance. The investigation employed field surveys, secondary data, and farm-level energy audits to assess mechanization across land preparation, transplanting, weeding, irrigation, crop protection, and harvesting-threshing. Mechanization levels were quantified using the Mechanization Index (MI) and energy-equivalent method, with farm inputs—human labor, draught animal power, fuel, electricity, and machine hours - converted to Mega Joules per hectare (MJ/ha) to estimate energy requirements. The effects of farm size, machinery ownership (individual vs. custom hiring), and crop establishment method (wetland transplanted vs. direct-seeded rice) were also evaluated. Findings indicate that the mechanization index has increased from 24% in the early 2000s to over 55% in 2023. Land preparation is the most mechanized operation (>85%), primarily using tractors, rotavator, and puddling implements. Mechanical transplanting using walk-behind and self-propelled transplanter is gaining adoption but remains limited to medium and large farms due to high investment and skill requirements. Harvesting and threshing achieved 70–80% mechanization, facilitated by combine harvesters and multicrop threshers, reducing turnaround time and post-harvest losses. In contrast, weeding, irrigation, and crop protection remain largely manual or semi-mechanized, highlighting potential for further development. Energy analysis revealed that mechanized farms saved 22–28% human energy and 15–18% total energy per hectare, while reducing crop establishment costs by 12–15%. Custom Hiring Centers (CHCs) significantly enhanced access to high-capacity machinery for smallholders. The study concludes that Chhattisgarh is shifting from partial to semi-intensive mechanization, and achieving sustainable, energy-efficient paddy production requires region-specific mechanization strategies, affordable modular machinery, and CHC expansion.

Keywords: *Chhattisgarh; Energy Efficiency; Farm Mechanization; Machinery*; *Paddy Cultivation.*

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Paper No.: IAEC 2025 - FMP- 08

Biomechanical Approach of Estimation of L4/L5 Lumbar Vertebra Load During Operation of Paddy Transplanter

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Abstract

A biomechanical analysis was conducted to evaluate and compare the stress on the lumbar vertebra (L4/L5) of operators using two types of paddy transplanters: a manually operated two-row hand-cranked model and an electrically powered two-row version. A controlled laboratory setup replicating field conditions was used to record body segment joint angles, incorporating typical body segment dimensions and weight of the Indian population. Field measurements of cranking and pulling forces were obtained using load cells. In the manual transplanter, peak horizontal and vertical forces on the lumbar spine reached at 90° and 270° crank position, respectively, while the highest moment (322.62 Nm) occurred at the 270° crank position. Horizontal and vertical forces acting on lumbar vertebra of e-powered transplanter operator were 73% and 17.7%, respectively, less than that of in existing manual paddy transplanter. Moment acting on lumbar vertebra was 31.6% less in e-powered transplanter compared to that of with existing transplanter. The removal of manual cranking in the e-powered transplanter led to a significant reduction in lumbar loading. The forces and moments on the lumbar region were notably lower with the e-powered model, highlighting its effectiveness in reducing musculoskeletal strain associated with manual operation.

Keywords: *Biomechanical Modeling; Lumbar Loading; Musculoskeletal Risk; Paddy Transplanter.*

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Performance Evaluation of Self Propelled Maize Harvester

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Abstract

Maize is a crucial cereal crop in India, third in significance after rice and wheat, accounting for only 2.4 % of global production despite extensive cultivation in Karnataka region. This affordable maize cob harvester is capable of cutting stalks, stripping cobs and collecting them in one pass and making it particularly useful for small land-holding farmers. The field performance trials were conducted in Agronomy Research Fields, University of Agricultural Sciences, Raichur, Karnataka state. The machine was tested for the effect of three forward speed of operation (1 km/h, 1.2 km/h, 1.4 km/h) with snipper speed (32 m/min, 39 m/min, 45 m/min) and measured stripping loss, length of stem before and after harvesting, number of cobs per hour, weight of cobs per hour, length of cut (stalk) and machine parameter such harvesting efficiency, cob picking efficiency, cob damage, actual field capacity, field efficiency and fuel consumption. Optimal performance was observed at a forward speed of 1.2 km/h and snipper speed of 39 m/min, achieving harvesting efficiency of 96.30 %, cob picking efficiency of 97.42 %, minimal cob damage at 1.10%, actual field capacity of 0.09 ha/h, field efficiency of 93% and fuel consumption of 1.13 L/h. Stripping loss and cut length were within acceptable limits and higher cutting efficiency was noted when increasing forward speed from 1 to 1.2 km/h. These findings indicate that, when operated under the optimal settings identified, the maize-cob harvester is highly effective on well-leveled terrain. It offers a promising, low-cost mechanized solution for small land-holders, significantly enhancing harvesting efficiency while minimizing crop damage and drudgery.

Keywords: *Cob Damage; Field Efficiency; Harvesting Efficiency; Maize Cob Harvester; Performance Evaluation.*

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Paper No.: IAEC 2025 - FMP- 10

Impact of Variable Sized Compartment Bunds on Soil Moisture, Rainwater Use Efficiency and Water Productivity of Green Gram in Semi-Arid Region

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Abstract

Compartment bunds are the most suitable method to harvest rainwater and conserve soil moisture; therefore, to study the soil moisture conservation, rainwater use efficiency and water productivity, three compartment bund sizes of 2.50×2.75 m, 2.50×3.50 m and 2.50×4.00 m were selected along with a control treatment. Soil moisture retention up to threshold level under compartment bunds observed for 30 days, whereas in control treatment moisture was retained up to 19 days only. The rainwater use efficiency under different treatments were compared and it was found that, the highest rainwater use efficiency of 1.818 kg/ha mm was observed under 2.50×2.75 m, compartment bund size, followed by 1.742 kg/ha mm under 2.50×3.50 m compartment bund size, 1.66 kg/ ha mm under 2.50×4.00 m compartment bund size and observed least under control treatment as 1.363 kg/ha mm. The water productivity under different treatments were compared and it was found that the highest water productivity of 0.857 kg/ m^3 was observed under 2.50×2.75 m, compartment bund size, followed by 0.821 kg/m^3 under 2.50×3.50 m compartment bund size, 0.786 kg/ m^3 under 2.50×4.00 m compartment bund size and observed least under control treatment as 0.571 kg/ m^3.

Keywords: *Compartment bunds; Rainwater Use Efficiency; Water Productivity; DMRT.*

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Paper No.: IAEC 2025 - FMP- 11

Modelling Body Segment Joint Angles in Hand Cranking Operation Using RSM

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Hand cranking is a widely used method of power transmission in agricultural tasks. This study aimed to assess the joint angles of key body segments during cranking of a manually operated two-row paddy transplanter under laboratory conditions. A graduated disc carrying visible markings at 45° intervals from 0° to 360° was mounted concentrically on the cranking shaft. Eighteen participants of the stature range of the 150 - 180 cm were categorized into six height groups, with three participants in each group. The participants were asked to operate transplanter to mimic the operation in field. The anatomical points on the body segment joints were highlighted with markers for easy detection, during measurement of inclination. The cranking operation of each participant was recorded using a DSLR camera at 60 frames per second in the sagittal plane. Using *Kinovea* software, the inclination of the lower arm, upper arm and trunk with respect to the horizontal was extracted from the video recordings. Response surface regression analysis was then applied. A cubic model was found suitable for estimating the lower and upper arm angles, while a quadratic model was appropriate for predicting trunk inclination. The values of coefficient of determination were found satisfactory implying suitability of models for prediction of key body segment inclinations with horizontal during cranking operation.

Keywords: *Crank Angle; Stature; Trunk Inclination; Upper Limbs' Inclination.*

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Paper No.: IAEC 2025 - FMP- 12

Precision Fertilizer Management through Prescription Mappings in Rice

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Abstract

Fertilizer management is vital for sustainable production of rice in the growing demand natured economy. Efficient fertilizer management can be done through various ways like precision fertilizer application, slow release fertilizers etc. One of important precision aspect of fertilizer management booming was Variable Rate Technology (VRT). VRT may be based on offline prescription maps or on-board (real-time) sensors for the data acquisition. In this study different fertilizer prescription maps including soil sampling based N, P,K, pH and EC maps, Leaf Colour Chart driven maps, multispectral imagery driven vegetation indexed maps were developed. These maps were compared; best maps were selected and converted into a usable data for the precision fertilizer application machinery. The study demonstrates the feasibility of various N prescription map development methods, incorporation to mechanization followed by a comparison. Through these maps VRT can be successfully adopted and it aids in sustainable paddy farming.

Keywords: *Drones; Mapping; Nitrogen; Rice; SDG 12 Responsible Consumption and Production; Site Specific Application.*

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Paper No.: IAEC 2025 - FMP- 13

Development of Manual Drawn Solar Powered Fertilizer Broadcaster

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Abstract

A manually drawn solar-powered fertilizer broadcaster was developed in the Department of Renewable Energy Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (India). The field performance of the solar-powered fertilizer broadcaster was evaluated. The variables selected for the study were the number of vanes on the spinning disc and the rpm of the spinning disc. The effect of these variables on the uniformity of fertilizer broadcasting, effective spread width, theoretical field capacity, actual field capacity, and field efficiency was studied. The battery charging behavior of the SPV-powered fertilizer broadcaster was observed under both no-load and load conditions. Not much variation was observed in the battery voltage due to continuous charging by the solar panel. It was noted that the battery voltage increased from 12.09 V at 09:00 h to 12.57 V at 18:00 h, with ambient temperature ranging from 28.2°C to 32.3°C under load conditions. The hopper of the fertilizer broadcaster was filled with 30 kg of fertilizer and operated at a fixed forward speed of approximately 1.50 km/h. The average width of fertilizer spreading was found to be 5.70 m, while the actual field capacity and field efficiency of the SPV-powered fertilizer broadcaster were recorded as 0.63 ha/h and 71.56%, respectively. The amount of fertilizer broadcasted within the width of 0 to 100 cm on both the left and right sides of the broadcaster was found to be 169.64 g and 164.56 g, respectively, at a disc spinning speed of 300 rpm with three vanes on the disc. The quantity of fertilizer broadcasted was observed to be uniform across all rows over a row length of 10 m. The average heart rate of various subjects during the operation of the manually drawn solar-powered fertilizer broadcaster was observed to be 107.6 beats/min, at an average walking speed of 1.52 km/h. The developed SPV-powered fertilizer broadcaster operated continuously for about 9 hours per day without significant variation in the initial battery voltage. The cost of operation was calculated to be Rs. 125 per hectare, with a 68% cost saving compared to traditional broadcasting method.

Keywords: *Fertilizer Broadcaster; Field Capacity; Field Efficiency and Heart Rates; Uniformity of Fertilizer Broadcasting.*

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Paper No.: IAEC 2025 - FMP- 14

High Value Vegetable Cultivation in Automated Hydroponic Structure: Profitable Business

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Abstract

The nutrient film technique (NFT) hydroponic structure with capacity of 500 m^2 with dimensions of 26 m long and 19 m wide and at a gutter height of 3.5 m and ridge height of 5.5 m was used in this study. It consists of a high-tech poly house with a size of. (01 unit), 200-micron UV-stabilized standard poly film with 85% light transmission a control room, fully automated climate-controlled panel, sensors, temperature controller-fan and pad control, humidity control, fogging system, nutrient tank, dosing & fertigation system. The study indicated that the temperature, relative humidity, light intensity and CO_2 inside NFT hydroponic structure was favorable for the growth of spinach and fenugreek in the all season. Temperature inside the hydroponic structure was found 5-6°C less than the outside temperature. The relative humidity inside the hydroponic structure was observed in between 30-67% in the month of July, August and September. The Relative humidity inside hydroponic structure was found 30-42% more as open field. The light intensity inside hydroponic structure was observed in between 50-60% more as compare open field. The Moisture content of Spinach was found (86.29%), iron content (112.19 ppm), chlorophyll content (43.14 mg/gm), fiber content of roots (2.84%), and leaf area (12.78 cm2) found in the hydroponic structure with NFT having growing media oasis cubes. Yield of spinach in the hydroponic structure with NFT having growing media oasis cubes was found greater (161.49 q/ha.) followed by in combination of coco-peat and vermi compost (128.332 q/ha) and soil media in the open field (99.78 q/ha).

***Keywords**: Autocontrol; Hydroponic; NFT; Spinach.*

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Paper No.: IAEC 2025 - FMP- 15

Performance Evaluation of Multi-Functional Vegetable Transplanter

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Abstract

The manual vegetable transplanting on raised bed, mulch and drip laying is time-consuming, laborious and increasing the cost of cultivation. To address this, a multi-functional vegetable transplanter was developed. The performance of the multi-functional vegetable transplanter was evaluated at three different speeds (0.8, 1.0, and 1.2 km/h) and plant-to-plant spacings (300, 600, and 1200 mm) with three replications. From the study it was found that increasing the forward speed improved the effective field capacity and field efficiency but also increased the Seedling Miss Index and Seedling Multiple Index, which are undesirable. The experimental results revealed that the developed machine at forward speed of 0.8 km/h and plant spacing of 300 mm could be operated for the minimum Seed Miss Index and Multiple Indexes with albeit sacrificing field efficiency. The developed machine significantly reduced labor costs by approximately 87% compared to traditional methods. The cost of operation per hour calculated based on time and area are, INR 1053 and 12015, respectively, with a payback period of 1.31 years. Multi-functional vegetable transplanter saved INR 8219 per hour (40.6%) compared to conventional methods. In conclusion, this machine successfully transplants the vegetable seedlings and is suitable for farm mechanization, providing cost savings and improved efficiency compared to the conventional methods.

Keywords: *Multiple Index; Savings in Cost; Seed Miss Index; Vegetable Transplanter.*

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Paper No.: IAEC 2025 - FMP- 16

Real-Time Disease Detection for Target Spraying in Vegetable Crops through Robust Deep Learning Models

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Abstract

Early detection of crop diseases is vital for precision agriculture and sustainable crop management. This study presents robust deep learning approaches for real-time detection in vegetable crops like tomato (*Solanum lycopersicum L.*) under field conditions, enabling targeted spraying interventions. A curated dataset of 6,451 tomato leaf images covering healthy and diseased samples at multiple severity levels was used to fine-tune four MobileNet variants, with MobileNet V3 Large achieving superior performance (99.88% accuracy, F1 score 0.996, inference time 67 ms), making it highly suitable for IoT- and smartphone-based applications. In parallel, the YOLOv10n model achieved strong results for binary classification (healthy vs. early blight), with precision 0.953, recall 0.945, mAP50 0.979, and mAP50-95 0.928, supported by convergence and reliability analyses. Collectively, these results demonstrate that MobileNet V3 Large and YOLOv10n offer accurate, fast, and scalable solutions for non-destructive disease detection, enabling real-time precision spraying and reducing indiscriminate pesticide use in smart farming systems.

Keywords: Deep Learning Models; Disease Detection; Target Spraying; Vegetable Crops.

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A 3-in-1 Hybrid Tractor System: Integrating Military-Grade CRDI, On-Farm Hydrogen Production, and Ethanol Blending for Sustainable Agriculture

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Abstract

This study presents a novel and versatile hybrid tractor system that unites three distinct fuel technologies—diesel, ethanol, and hydrogen - into one rugged platform tailored for sustainable farming. Inspired by the reliability standards of military-grade engineering, the system incorporates a high-pressure Common Rail Direct Injection (CRDI) system (2,500 bar) adapted from TATRA trucks, offering superior durability in harsh rural conditions. Reinforced with cyclone air filtration and heavy-duty forged steel parts, the tractor is built to withstand extreme operational stress. The hybrid setup allows seamless transition between three fuel types: traditional diesel for high-demand tasks, ethanol blends (E20 to E85) using specially treated corrosion-resistant injection ports, and hydrogen via either spark ignition or dual-fuel combustion with diesel. A smart triple-mode ECU manages fuel selection dynamically to optimize performance, cut diesel consumption by up to 40%, and reduce carbon emissions by nearly 50% when operating in hydrogen mode. Farmers can produce their own hydrogen through solar-powered biogas reformers, converting agricultural waste into clean fuel—approximately 40 kg of hydrogen from one ton of crop residue, supporting up to 200 hours of tractor use. Materials vulnerable to corrosion and embrittlement are addressed through polymer-coated stainless steel and anodized aluminium components. This solution is not only eco-friendly but also economically beneficial, helping farmers save around INR 90,000 in annual fuel costs while offering an added income stream of INR 30,000 per month from hydrogen sales. Successfully piloted in Punjab and Maharashtra, the system aligns with national policies on ethanol blending and hydrogen energy, making it a transformative leap toward energy-resilient agriculture.

Keywords: *Dual-Fuel Combustion; CRDI Retrofit System; Hybrid Tractor Technology; On-Farm Hydrogen Production; Sustainable Agricultural Mechanization.*

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Paper No.: IAEC 2025- FMP – 18

Double transplanting: A Silent Resilient and Sustainable Technology for Rice Production in Madhesh Province of Nepal

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Abstract

The global concern of climate change and expansion of drought areas in Madhesh province had made a challenge in rice production. The increase of productivity of rain-fed rice crops ensuring the natural resource management is essential for feeding the growing population. Based on this concept, the study was conducted to evaluate the promising farm innovative and adaptation practices used by small-medium landholdings farmer in Bardibas, Mahottari, Madhesh province, Nepal. A 2-3 years field surveys and FGDs was undertaken to compare the single transplantation (ST) and double transplantation (DT) on crop growth, yield, climate resilience, and overall sustainability i.e. social (involvement of women and labor productivity), environmental (water productivity and nutrient use efficiency), and economic (benefit: cost ratio) dimensions of sustainability. The plantation of rice and nursery management was done based on the changing climate scenario. The DT practices of rice grower believes rice yield increase by 20-50% higher than ST), more percent fertile tiller and also increases yield indices, water and labour productivity, and the benefit-cost ratio. The DT practice also resulted in early maturity (15-20 days earlier than ST), created more women-friendly and improvement, decreased lodging and pest/disease incidence, as well as subsequent reduction in the use of synthetic chemical pesticides and associated environmental costs. But no improved variety was developed for this technology. The DT cultivation practices with appropriate variety, with other agronomic management practices, are essential for large-scale sustainable rice production under changing climatic conditions.

Keywords: *Double Transplanting; Climate Resilience; Sustainability; Rice; Productivity.*

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Effect of Solvent, Time and Particle Size on Yield of *Simarouba glauca* Oil

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Abstract

Simarouba glauca kernel oil was extracted by using three solvents namely n-hexane, acetone and ethyl acetate. The factors considered for extraction of oil were extraction time (1-3 hours), solid-solvent ratio (0.05-0.25 g/ml) and particle size of grounded *Simarouba glauca* kernel (0.6-1.0 mm) and Box-Behnken design of RSM (Response Surface Methodology) was used for modelling the process of oil extraction. The effect of each factor (independent variable) on oil yield was discussed by using suggested model of R^2 values of 0.9974, 0.9873 and 0.9884 for n-hexane, acetone and ethyl acetate, respectively. An optimization study by using genetic algorithm showed that the oil yield of 67.03% would be maximum for n-hexane with extraction time of 3 hours, solid-solvent ratio of 0.05 g/ml and particle size of 0.636 mm. The physiochemical properties of extracted oil was satisfactory and there was no significant change in the behaviour of FT-IR spectrum for each of solvent.

Keywords: *Simarouba glauca; solvent extraction; Box-Behnken design; RSM; optimization.*

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IAEC 2025 - FPE - 02

Impact of Plasma Activated Water (PAW) on Polyphenols, Antioxidant Properties and Anti-Nutrients of Sweet Orange (*Citrus sinensis*) Peel Powder

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Abstract

Valorization of sweet orange (*Citrus sinensis)* peels into wealth technology by using the non-thermal process considered to be noteworthy. The present investigation was performed to study the impact of plasma activated water (PAW) on physicochemical properties, polyphenols, antioxidant activities (DPPH, FRAP) and anti-nutrients (phytic acid and tannin) of sweet orange peel powder. The sweet orange peel was soaked in PAW treated at 10 kV for 30 min. followed by hot air drying at 40ºC for 1 h and 2 h. The results indicated that PAW treated samples (10 kV, 1 h soaking and 10 kV, 2 h soaking) enhanced total phenols (270.36±8.60; 291.07±5.39), total flavonoids (201.71±5.14; 237.15±5.50) and antioxidant activities (37.55±0.09; 39.32±0.27) significantly. All physicochemical properties of PAW treated samples differed significantly. The reduction in the anti-nutrients in PAW treated samples was achieved as compared to control samples C_1 (1 h soaking in distilled water) and C_2 (2 h soaking in distilled water). Diffractograms revealed that an increase in the relative crystallinity might be due to action of reactive nitrogen species (RNS) and reactive oxygen species (ROS) generated in PAW. The potential application of PAW treated sweet orange peel powder can be used in the formulation of nutraceutical and functional novel food products.

Keywords: *Sweet orange peel powder; Plasma activated water; Phenols; Flavonoids.*

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IAEC 2025 - FPE - 03

Development and Evaluation of IoT based Onion Storage in Bangladesh

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Abstract

Post-harvest losses of onions due to inadequate storage conditions remain a critical challenge in developing countries, particularly in Bangladesh where traditional methods lead to significant economic and food security impacts. This study presents the development and evaluation of an IoT-based smart storage system that optimizes storage conditions through automated temperature and humidity regulation to extend onion shelf life. Comparative study with traditional storage conducted over a period demonstrated that 26.8% (19.96% vs. 27.27%) reduction in weight loss and a 75.9% suppression of sprouting in the smart storage system, demonstrating its efficacy in mitigating dehydration and physiological degradation. Regression models confirmed strong relationships between external environmental factors and storage conditions, with smart temperature exhibiting a high correlation with traditional temperature (R^2 = 0.973) but greater stability due to controlled airflow. Relative humidity trends were predominantly influenced by outside storage levels (R^2 = 0.834), though the IoT system maintained lower variability. Fan runtime of 6–7 hr/day was identified for appropriate storage conditions. Using locally available materials, sensors, including DHT22, MQ-135, RTC and MQ-136 were integrated with an ESP32S3 microcontroller and the Blynk IoT platform, the system provides continuous data acquisition and remote management, thereby ensuring precise climate control within the storage facility. These findings emphasize the potential of an IoT- driven solution in enhancing onion storage efficiency, reducing storage losses and contributing to agricultural sustainability.

Keywords: Food Security; IoT-Based Storage; Onion, Shelf Life, Storage Losses.

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IAEC 2025 - FPE - 04

Effect of Drying Methods on Quality of Cocoa (*Theobroma cacao* L.) Beans

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Abstract

Cocoa is the chief ingredient in the making of chocolates, health drinks, cosmetics and even pharmaceuticals. After the harvest of ripe cocoa pods, followed by a brief storage of pods, pods are broken to remove the beans. Beans are fermented and dried. In this study, the cocoa beans fermented by heap method on plantain leaves were dried by different drying methods (open sun drying, green house solar tunnel drying and mechanical tray drying at 35, 45 and 55°C) by varying drying layer thickness (single, double and 5 cm layer). The quality of dried cocoa beans were evaluated for the moisture content, bean count, bean texture, pH, titratable acidity, free fatty acid content and fat content following the standard procedures. Irrespective of the treatment, the brown bean percentage ranged around 85%, tray dried samples recorded the less brown bean count when compared to sun and solar dried samples. The pH of all the samples ranged above 5 and solar dried samples recorded less acidic with a pH of 5.18 and the titratable acidity of 1.93 meq of NaOH per 10 g of sample. Thus, the quality parameters of the solar and sundried samples were on par and tray dried samples produced high acidity beans. The sun dried samples contained less polyphenols when compared to the solar tunnel dried and tray dried samples. There was no significant difference among the various drying layer thickness within the drying treatments. The tray dried samples contained the highest polyphenol content (9.69 mg/g in single layer) and sun dried samples showed the lowest total polyphenol content (5.32 mg/g in double layer). The epicatechin and catechin are the flavan-3-ol present in cocoa beans. The drying method had a significant effect on epicatechin content of the sample. The epicatechin and catechin content of the samples varied from 1.21to 2.83 mg/g and 0.03 to 0.14 mg/g, respectively. Sensory evaluation of the chocolates prepared with cocoa samples obtained from various drying experiments was conducted. The chocolate samples prepared from the solar and sun dried bean samples scored an overall acceptability of more than 7, confirming that the double layer bed thickness beans dried under the sun showed good colour, taste and over all acceptability.

Keywords: *Drying; pH; Polyphenols; Quality Parameters; Sensory Evaluation.*

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Multi-Objective Optimization of Jute Decorticator Performance by Discrete Element Method and Integrated Deep Neuro-Fuzzy System-NSGAII

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Abstract

Jute (*Corchorus sp*.), globally recognized as “golden fibre” is one of the best natural fibres in the world used for various textile and non-textile applications for over 150 years due to its high tensile properties, low extensibility, high thermal insulation, biodegradability, and environmental friendliness. Production of jute fiber having excellent quality to meet global requirements is an important concern in the context of its application in the diversified area, which is mainly controlled by the extraction and retting process. To address these issues, this research work aimed to develop an electric power-operated jute ribbon extractor (decorticator) to reduce the total processing cost and increase the quality of fibre. In this study, Creo Parametric software was used to develop the 3D model of the jute ribbon extractor, and EDEM software was used as a simulation tool to predict the various forces acting on the decorticating unit using the discrete element method. For establishing the proper interaction between jute plants/sticks and machine parts, the Hertz-Mindlin (No-slip) model was employed during the simulation process. The simulation results predicted that, as the operating RPM increases, the torque required to extract the ribbon from jute plant decreases, but the total power increases. The simulation results show that the total power required to operate the extractor at 100, 200, 300, 400 and 500 RPM was 2.4, 4.1, 5.4, 6.0 and 6.3 kW, respectively. Based on the simulation results, a prototype was developed and decorticator performance was optimized using the Integrated deep neuro-fuzzy system-NSGAII model. The DNFS with three learnable membership functions (Gaussian, Generalized Bell-shaped, Triangular) was developed to predict performance parameters of a decorticator. The optimum parameters obtained from the study are plant age of 90 days, number of blades 17, blade size is 65 and speed of 450 rpm with Ribbon separation efficiency of 89.08, Throughput capacity of 1039.25 and specific energy requirement is 3.30. The validation trials demonstrated a ribbon separation efficiency of 91.2%, compared to a simulated result of 89.08%, throughput capacity was measured at 1037.12, in contrast to the predicted value of 1039.25. Additionally, the specific energy requirement was 3.42, while the predicted result was 3.30

Keywords: *Deep Neuro-Fuzzy System; Discrete Element Method; Jute; Learnable Membership Functions; NSGAII; Specific Energy.*

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Impact of Vibration and Packaging on Postharvest Quality of Pear Fruit

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Abstract

This study aimed to evaluate the effectiveness of two packaging types in preserving the quality of pear fruit under simulated vibration conditions, compared to a control (no packaging and no vibration). The first packaging type was a newly developed design produced using recycled Polyethylene Terephthalate (PET) via 3D printing technology. The second was a commercially available reusable plastic container (RPC). Pear fruits were packed in both types of packaging and subjected to vibration using a vibration table for 2 hours at a frequency of 2.5 Hz. Control samples were not vibrated. All samples were stored at room temperature (22°C) for six days, and measurements were taken at 3-day intervals. Key parameters assessed included package transmissibility, vibration occurrence, weight loss, and fruit color. Statistical analyses such as ANOVA and correlation tests were performed. During simulated transport, a total of 825 and 651 acceleration peaks were recorded in the intervals of 0.233–0.512 g and 0.203–1.336 g in the 3D-printed package and RPC, respectively. The new 3D package demonstrated fewer occurrences of high acceleration. Additionally, package transmissibility measurements over the storage period showed that the 3D-printed package had lower transmissibility than the RPC, highlighting its ability to reduce the transfer of vibration to the fruit. Weight loss was highest in vibrated samples packed in the RPC, while the control group (no vibration) showed the least weight reduction. After six days of storage, pear fruits in the 3D-printed package retained the highest *L** (lightness) values, indicating better visual quality. These findings support the potential of the new 3D -printed package as an efficient and sustainable alternative to conventional packaging, offering improved protection against vibration-induced quality loss during transportation and storage of fresh produce.

Keywords: *Pear Fruit; Packaging Transmissibility; Quality Simulated Transport; Vibration.*

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IAEC 2025 - FPE - 07

Quality Classification of Mango Using Computer Vision System

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Abstract

Around the globe, computer vision systems have drawn a lot of attention as a quick and non-destructive method for assessing the qualitative qualities of agricultural products. Size, shape, skin and flesh color, flavor, sweetness, and scent are some of the physical characteristics of mango fruit that affect its quality. Researchers' interest in non-destructive approaches has grown over the past several years as prospective technologies that might be utilized for fruit quality assessment as part of postharvest processing. The current trends in non-destructive procedures are more effective, less expensive, and produce faster and more precise outcomes. The purpose of this work is to create a computer vision system (CVS) that analyzes images from digital photography and computer vision to determine the color of mango surfaces. A computer vision system was used to classify different varieties of mango using color features (RGB, HSV, Hue and Chroma, Gray, and *L*, a** and *b**) extracted from mango images. The results revealed that although there are variations within the samples of the same variety, it is possible to differentiate or classify 100% from the extracted features, which is completely impossible by human expertise or even from the chemical analysis data of mangoes done by destruction of mango samples as well as by laborious techniques. Four different types (Amrupali, packet Jhinuk, Ashwina and Jhinuk) of mango (94.62% correctly classified), three different types (Amrupali, packet Jhinuk and Ashwina) of mango (100% correctly classified), and day wise (Jhinuk) (74.77% correctly classified) were considered at the same time. The chemical compositions (moisture content, titrable acidity, vitamin C, TSS, and pH) were determined. Among the four different varieties of mango, the highest moisture content (84.22 ± 3.44%), TSS (21.75 ± 3.32°Brix), and pH (4.1 ± 0.3) and the lowest titrable acidity (0.34 ± 0.03%) and vitamin C (33.18 ± 1.48 mg/100g) were found in Ashwina. Jhinuk has been observed for 4 days. The highest moisture content (85.22 ± 1.67%), TSS (23.60 ± 2.67°Brix), pH (5.01 ± 0.3), and the lowest titrable acidity (0.28 ± 0.02%) and Vitamin C (27.26 ± 2.67 mg/100g) were found in day 4. Vitamin C and titratable acidity contents were decreasing, but moisture, pH, and TSS were increasing from harvesting to ripening stage. The findings from the research indicate that computer vision systems seem to be a good alternative for objectively quantifying standard color without destroying the sample.

Keywords: *Ashwina; Color of Mango; Computer Vision System (CVS); Jhinuk; pH; TSS.*

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Effect of Tray Drying on the Quality of Soybean

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Abstract

Soybean is a major crop grown in the Vidarbha region of Maharashtra. The harvesting season generally falls during the rainy period, particularly from September to October. During harvesting and threshing, soybeans have high moisture content, which leads to storage losses. Therefore, an experiment on soybean drying was conducted to study the effect of drying on the quality of soybean. Soybeans (variety PDKV Amba, Dr. PDKV, Akola) with an initial moisture content of 25% were dried in a tray dryer at a temperature of 60 °C. The total drying time required to reduce the moisture content of soybean from 25 % to 10.03 % (wb) was found to be 180 minutes.The average drying rate of soybean at 60 °C was found to be 0.522 g/min.The cracking percentages, bulk density, degree of shrinkage and rehydration ratio of dried soybean was found to be 45.79 %, 666.92 kg/m^3, 0.243 and 1.960, respectively. The thousand-grain weight of soybean kernels was decreased from 160 g to 132.57 g during drying. The colour values *L*, a*,* and *b** changed from 48.30 to 56.96, 2.93 to 2.44, and 11.12 to 13.08, respectively.

Keyword: *Cracking Percentage; Degree of Shrinkage; Drying rate; Moisture ratio; Rehydration Ratio; Tray Dryer*

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IAEC 2025 - FPE - 09

Non-Destructive Imaging and Deep Learning for Quantitative Detection of Chickpea Flour Adulteration

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Abstract

Ensuring authenticity in staple food commodities is a pressing global challenge, particularly as economic incentives drive the adulteration of high-value products with visually similar, lower-cost substitutes. Chickpea flour, widely recognized for its nutritional and functional value, is increasingly subject to adulteration with yellow pea flour and corn flour. Conventional analytical methods such as chromatography, protein assays, and spectroscopy, while reliable, are often unsuitable for large-scale, rapid monitoring due to their destructive and resource-intensive nature. In this study, we developed a novel non-destructive framework integrating RGB-based digital imaging with convolutional neural networks to quantify adulteration levels in chickpea flour. Image datasets were prepared at varying levels of adulteration, pre-processed for surface uniformity, and classified using a deep learning architecture optimized on the SentiSight platform. The model achieved high classification accuracy across trained classes and demonstrated the capacity to interpolate untrained adulteration levels with prediction errors as low as ±3 percent. Results demonstrate that digital imaging with AI is a scalable, eco-efficient alternative to laboratory testing, enabling rapid food fraud detection in industrial and regulatory settings. This approach also supports innovation in product development and strengthens value-added product markets by ensuring authenticity and consumer trust providing opportunities to support innovation in new product development and to strengthen the value-added products market by ensuring quality across the food supply chain

Keywords: *Deep Learning; Digital Imaging; Flour Adulteration; Non-Destructive Testing; Food Fraud Detection.*

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IAEC 2025 - FPE - 10

Modification and Testing of Pedal Operated Cashew Nut Desheller

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Abstract

India is one of the largest producers of cashew nuts, with small-scale industries predominantly using manually operated deshellers. These systems often cause operator fatigue and exposure to Cashew Nut Shell Liquid (CNSL). This study presents the modification and testing of a pedal-operated cashew nut desheller designed to reduce physical strain and improve deshelling efficiency. The deshelling mechanism integrated cutting and splitting operations in a single stroke using a quick return motion mechanism. Design parameters, including crank length, saddle height, and handle dimensions, were based on anthropometric data of users. Safety and structural enhancements were made by adding covers and improving ergonomics and aesthetics. Key components included a base frame, body cover, storage tray, and hopper. Performance evaluation with four subjects showed the desheller required light physical effort, with overall discomfort rating method (ODR) and body part discomfort score (BPDS) values of 4.3 and 17.6, respectively. The machine achieved a mean shelling capacity of 1.58 kg/h, whole kernel recovery of 69.6%, and WB ratio of 6.7. The modified design proved to be a safer, more efficient solution for small-scale cashew processing units, offering enhanced productivity and reduced operator fatigue.

Keywords: *Kernel Recovery; Shelling Capacity; Whole Kernel Recovery; WB Ratio.*

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Black Rice Quality Profiling and Application of E-Nose Technology in Storage Pest Monitoring

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Black rice (*Oryza sativa* L.), particularly the indigenous varieties Chakhao Amubi and Chakhao Poireiton from Manipur, is widely recognized for their rich nutritional profile and traditional significance. However, its storage stability is a major concern due to vulnerability to insect infestation, which compromises quality and reduces shelf life. Conventional detection methods for pest infestation are destructive, time-consuming, and often ineffective for early detection. Thus, rapid, non-destructive tools such as electronic nose (E-nose) systems are gaining attention for their potential application in storage pest monitoring. In this study, real-time detection of storage pests by E-nose system was developed for Chakhao Amubi and Chakhao Poireiton varieties. Nutritional profiling included determination of protein, fat, ash, crude fibre, and carbohydrate contents. An E-nose prototype was developed using five gas sensors (acetone, hydrogen, ammonia, carbon monoxide, and isobutane) to detect volatiles emitted from infested rice. Data analysis involved ANOVA, coefficient of variation, correlation analysis, and feature extraction metrics such as Relative Integral (RI), Response Change (RC), and Maximum Deviation (MD). Machine learning regression models such as Partial Least Squares Regression (PLSR), Support Vector Regression (SVR), and Gaussian Process Regression (GPR) were applied to assess prediction accuracy. Chakhao Amubi had higher protein (10.19 ± 0.17%), ash (1.78 ± 0.04%), fat (1.67 ± 0.11%), and crude fiber (1.67 ± 0.10%), while Chakhao Poireiton contained higher carbohydrates (76.36 ± 1.04%). Among the sensors, ammonia and isobutane exhibited the highest stability, while acetone was most sensitive to volatile changes caused by infestation. Regression analysis showed that the GPR model achieved the best performance (R^2 = 0.92, RMSE = 2.23), outperforming PLSR and SVR, confirming its robustness for pest detection. This study demonstrates that nutritional profiling of black rice, combined with E-nose technology, provides a powerful tool for ensuring grain quality and storage safety. The developed E-nose system enables rapid, non-destructive detection of pest infestation, offering a novel and sustainable solution for post-harvest grain management. The integration of sensor technology into storage practices can reduce post-harvest losses and contribute to improved food security and value addition of black rice.

Keywords: *Black Rice; Electronic Nose; Nutritional Profiling; Sensor Technology; Storage Pest.*

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Paper No.: IAEC 2025- FPE- 12

Citrus Leaf Disease Detection Using Quantum Convolutional Neural Networks (QCNNs)

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Abstract

Timely and accurate identification of citrus leaf diseases is essential for sustaining agricultural productivity, particularly in resource-limited environments. While conventional deep learning models, such as Convolutional Neural Networks (CNNs) have demonstrated strong performance in plant disease classification, their significant computational demands limit their feasibility for deployment on edge or mobile devices. In this study, we present a Quantum Convolutional Neural Network (QCNN) framework for citrus leaf disease classification of six categories: blackspot, Cranker, Greening, Healthy, Powdery, and Sooty Mould. By leveraging the computational advantages of quantum systems, including exponential state representation and logarithmic parameter scaling, the proposed QCNN architecture delivers classification functionality with substantially reduced resource requirements. The model integrates hybrid quantum-classical components, variational quantum circuits, and efficient encoding mechanisms, offering a promising alternative to classical methods. This work highlights the potential of QCNNs in advancing precision agriculture and supports the broader goal of enabling quantum machine learning in data- and compute-constrained environments.

Keywords: *Quantum Convolutional Neural Networks; Citrus; Leaf Disease.*

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Citrus Leaf Disease Detection Using Efficient and Explainable CNNs

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Abstract

Early and accurate detection of citrus leaf diseases is critical for minimizing crop loss and improving the resilience of agricultural systems. In this study, we present an efficient and interpretable deep learning framework for the classification of six citrus leaf conditions: Blackspot, Cranker, Greening, Healthy, Powdery, and Sooty Mould, using a custom labeled image dataset created as part of this work. To address dataset instability and variability in image quality, we employ a semi-automated pre-processing pipeline using Label Studio for manual leaf region annotation, followed by uniform cropping and resizing to 256×256 pixels.

We evaluated both Convolutional Neural Network (CNN) and multiple transfer learning models, including MobileNetV2, ResNet50, and EfficientNetB0, pre-trained on ImageNet. All models are fine-tuned on the curated dataset using TensorFlow, with training enhanced by data augmentation, early stopping, and performance monitoring via Tensor- Board. The results demonstrate that while the CNN achieves strong performance with fewer parameters—suitable for edge deployment—transfer learning models yield superior classification accuracy, particularly when trained on the cleaned and resized dataset.

To promote transparency and trust, we integrate Grad-CAM visualizations to interpret model decisions and localize disease-relevant regions in the leaf images. The study highlights the significance of dataset preparation, model interpretability, and benchmarking across architectures for deploying robust and scalable AI solutions in smart agriculture. Our framework is particularly suited for low-resource environments where precision farming tools are urgently needed.

Keywords: *Explainable Convolutional Neural Networks; Citrus; Leaf Disease.*

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IAEC 2025 – REE – 01

Modelling of CO_2 Emission on Dairy Farms Using ANN – A Case study in Canterbury Province, New Zealand

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Abstract

This study was conducted pastoral (PDFs) and barn (BDFs) dairy farming systems in New Zealand, where on average, electricity and fertiliser were the main sources of CO_2 emission. In this study, several direct and indirect factors have been identified to create an artificial neural networks (ANN) model to predict CO_2 emission in milk production in different conditions on New Zealand dairy farms. The final model can predict CO_2 emission based on farm conditions (size of crop area), farmers' social considerations (level of education), and energy inputs (electricity, N and P use and irrigation frequency), and it predicts energy use in New Zealand Dairy farms.

Keywords: *Modelling CO_2 emission; Energy Consumption; Neural Networks; Dairy Farming.*

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IAEC 2025 - REE - 02

Effects of Pretreatments and Performance of Hybrid Solar Dryer on Drying Moringa Leaves in Bangladesh

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Abstract

Drying is an ancient way of food preservation which solves the problem of over-production during the peak harvest season and also crates new varieties of food products. However, traditional sun drying is associated with poor product quality, slow and weather dependent drying and other limitations. Modern hybrid solar dryers like, Bangladesh Agricultural University Hybrid Solar dryer (BAU HSD) can be effectively used for solving these problems and overcome the limitations of sun and solar drying. This study focuses on the performance and viability of BAU HSD for drying of moringa, a nutrient enriched herbal plant leaves with three different pre-treatments (Blanching, Blanching+0.5% KMS and Blanching+0.1% MgO + 0.1% $NaHCO_3$) with control samples. However, the drying performance the BAU HSD asses in terms of drying rate, temperature distribution and effect of pre-treatment on drying kinetics. Moringa leaves were dried in the BAU HSD as well as open sun and compared. Three 1kW PTC heater with blower and chimney controlled by ESP32 microcontroller were used to keep the drying temperature between 45°C and 55°C. The results show that the drying temperature inside the dryer was between 39.6°C and 56.1°C which consistently maintained the internal temperature of the dryer between 13°C and 17°C higher than the ambient temperature. The average relative humidity (RH) of the drying air was 27.53%, which is 22.71% lower than average ambient RH. Three replications of the experiment were done where the average initial moisture content (MC) on wet basis (w.b) of samples were 72.51%, 73.41% and 65.26% which were reduced to final MC (w.b) of 4.09%, 4.33% and 5.21% on average, respectively. Meanwhile the open sun dried samples were reduced to moisture content of 19.51%, 14.42% and 11.48% (w.b), respectively for the same drying period and it took about 3 to 4 hours additionally to reach the same MC as the HSD ones. The overall drying rate of moringa leaves inside the dryer found to be 9.5% MC/h, while it was 7.4% MC/h for OSD. The results prove the effectiveness of BAU HSD over sun drying by reduced drying time and weather independent drying. While pretreatments like blanching can further shorten the drying time, it may also affect the nutritional quality which requires additional study. This dryer offers a good drying solution for small and medium scale farmers due to its simple operational procedure and auxiliary heating option.

Keyword: *Hybrid Solar Dryer; Moringa; Pre-treatments; Smart Dryer; Herbal Plant.*

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IAEC 2025 - REE - 03

Microplastic Pollution on Agriculture: Sources, Risks, and Mitigation Strategies

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Abstract

Plastic pollution, especially microplastics, has become an alarming environmental issue with significant implications for agricultural ecosystems. Plastics used in agriculture, such as mulch films, drip irrigation parts, and seed coatings, are becoming more and more common. Over time, these materials can break down into microplastics and leak into soils, nearby water sources, and even into groundwater. The widespread use of plastic mulch, microplastic containing wastewater for irrigation, and inappropriate disposal of plastic waste are some of the causes of microplastic contamination in agriculture. The main objective of this presentation is to discuss the possible effects of microplastics on crop yields, plant growth, microbial populations, as well as soil quality. Concerns about microplastics entering the food chain and potential hazards to human health are also report in recent literature. The talk also looks at modern mitigation techniques like better trash management, biodegradable substitutes, and creative farming methods that lessen reliance on plastic use in agriculture. In order to gain a deeper understanding of microplastic transport, accumulation, and long-term impacts on soil health and food safety, future study directions will be presented. To ensure sustainable farming methods, protect the environment, and preserve public health, it is imperative that plastic pollution in agriculture should be addressed with priority.

Keywords: *Environment; Hazards; Micro plastics; Pollution; Public Health.*

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SMART-SIP+: Approaches to Downstream Energy Utilization from Solar Irrigation Pumps in Bangladesh

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Abstract

The energy-water-food nexus is critical for Southern Asian countries, due to its interconnected nature, which directly impacts sustainable development. Bangladesh is ranked 7th in the Climate Risk Index. Only 1.3% of the electricity comes from renewable sources. Access to grid power is unreliable, and energy poverty is widespread. 60% of the population (100 M people) rely on agriculture as main income. Pumps are critical, in particular for crops raised during dry season. Six million irrigation pumps are used, powered by diesel engines consuming 1.4 MT imported diesel (4% of Bangladesh's annual emission) per year. Lack of cold chain effects post-harvest losses of high value fruits and vegetables ranging from 25-40% and on prices due to surplus during peak seasons. Harnessing the energy-water-food nexus is crucial for Bangladesh to achieve sustainable development, ensuring efficient resource use, enhanced food security, and resilient communities. The aim of this project is to enable a scalable clean energy transition in rural communities in Bangladesh by designing, implementing and demonstrating an integrated smart energy system which exploit the excess electricity from SIPs for powering Cold Storages and other alternatives to increase food security and develop incomes for local communities. The research project is funded by UK Research and Innovation's Ayrton Fund which aims to give developing countries access to the latest cutting-edge tech for reducing their emissions and meeting global climate change targets. A focus is given on resilience, profitability and maintainability of the energy systems, to ensure long term impact in communities. The research project is expected to optimize Smart-SIP minigrids, with a focus on efficient and enabled O&M, through IoT and AI. However, new business models (cold storage, processing of crops, reduced energy costs) will be introduced to increase farmer income and improve energy access. Besides, women and marginalized groups will be empowered by reducing drudgery tasks. Increasing entrepreneurship by improving access to energy. Moreover, developed SMART-SIP+ might help to reduce diesel use and lower CO_2 emissions.

Keyword: *Cold Chain; Crop Processing; Renewable Energy; Emission SMART-SIP; Solar Irrigation.*

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Pretreatment-Induced Variations in Thermochemical Properties and Ash Transformation Behavior of Jute and Hemp Stick Biomass

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Abstract

In recent years, India's energy landscape has increasingly pivoted towards renewable and environmentally sustainable sources, largely motivated by the need to reduce greenhouse gas (GHG) emissions and mitigate the impacts of global climate change. Among these renewable options, agricultural residues offer significant potential to contribute to both energy generation and food security. Biomass, when partially substituted for coal, presents a viable strategy to lower carbon dioxide emissions and promote cleaner energy production. However, the co-firing of biomass with coal can significantly influence ash composition and behaviour, thereby affecting combustion efficiency and operational stability in thermal systems. This study investigates the effects of various pretreatment techniques namely torrefaction, acid washing, and water washing on two lignocellulosic biomass types: jute stick and hemp stick. These pretreatments aim to enhance the suitability of the biomass for large-scale combustion applications by minimizing ash-related issues. The research focuses on evaluating mineral transformations and ash behaviour resulting from each pretreatment approach, in comparison with untreated biomass. A suite of analytical tools including X-ray fluorescence (XRF), ash fusion temperature (AFT) analysis, X-ray diffraction (XRD), thermogravimetric analysis (TGA), and scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDS) were employed to characterize the samples. Additionally, key slagging and fouling indices were assessed to understand deposition tendencies and process compatibility. The findings reveal that the applied pretreatment methods significantly influence the inorganic composition and ash transformation pathways of the biomass. These changes, in turn, affect the ash melting behaviour and deposit formation potential under thermal conversion conditions. Notably, the impact of each pretreatment varied between jute and hemp sticks, underscoring the importance of biomass-specific strategies for optimizing thermochemical performance in industrial applications.

Keywords: *Biomass; Pretreatment; Influential Element and Mineral; Slagging and Fouling.*

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IAEC 2025 - REE – 06

IoT Based Real Time Monitoring of Rooftop Solar Power Plant and Its Potential Assessment for Agriculture Production

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Abstract

Rooftop Agrivoltaics Systems (RAVs) offer a sustainable solution to urbanization, energy demand, and food security challenges by integrating photovoltaic (PV) panels with rooftop farming. This system allows for the cultivation of crops or vegetation on rooftops while also generating solar energy. The monthly performance of 76.8 kWp consisting of 240 mono-crystalline PV modules, each having a rated capacity of 320 Wp and are arranged in 12 parallel strings, with 20 modules per string, connected in series to achieve the required voltage was evaluated. The output of roof top solar power plant in term of current, voltage and energy output corresponding to weather parameters and solar intensity were monitored using IoT based sensors, smart Net meter and data logging system during 2022-24. The shadow analysis of solar PV panels over the crop coverage area between the solar panel strings were monitored on daily basis at 9.00 hr, 12.00 hr and 16.00 hr consecutively for two years. To quantify the impact of shading on the PV modules and crop area, the shadowed and sunlit regions were measured using SketchUp's Tape Measure Tool. The result revealed the energy output in the tune of 1,04,893kWh per year in term of energy generation and shadow analysis shows the potential for production of vegetable crops using the roof top agrivoltaics system, The dual use of roof for energy and agriculture production provides the sustainable solution in urban environment.

Keywords: *Agri Voltaic; Output Energy; Roof Top Solar Power Plant; Shadow Analysis.*

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Optimization of Microwave Pyrolysis for Biochar Production from Agroforestry Byproducts: Exploring Parameters and Operational Modes

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Abstract

Microwave assisted pyrolysis offers a rapid, energy efficient route to convert agroforestry residues into high value biochar but is hindered by hotspots, temperature non-uniformity, imprecise measurements, partial carbonization, and poor replicability. This study comprehensively investigates process variables, operating modes, and quantification techniques to address key challenges and to optimize biochar production. Hundreds of systematic experiments were conducted on various agroforestry residues, examining more than ten control parameters and classifying them by their impact on yield and quality. Four operating modes were investigated: constant power with/without high-temperature alarm, fixed temperature, and controlled heating-rate; and two novel metrics (carbonized amount and absolute yield) were introduced alongside traditional metrics to more accurately quantify biochar production and quality. Additionally, a central-composite response-surface design (30 runs at 300–700 W and 20–60 min.) applied to oak sawdust, perilla stem and rice straw to model seven responses for optimization. Power and process time emerged as the primary drivers of yield and carbonization; heating rate and target temperature acted as fundamental dependent factors. Constant-power operation without alarm achieved the highest reproducibility and absolute yield (up to 33.85%), whereas controlled ramping produced biochars with HHV >30 MJ/kg and fixed carbon >70%. Response surface model demonstrated excellent fits (R^2 up to 0.96) and confirmed that power and time significantly influenced all responses. Carbonization and HHV stabilized from optimal thresholds, while absolute yield peaked at 500 W/40 min. Energy efficiency was maximized at 500 W/20 min (70.8% for oak, 54.1% for perilla, 58.4% for rice straw). Multi-response optimization identified a global optimum at 616 W/26 min for oak and optima of 590 W/20 min (rice straw) and 594 W/29 min. (perilla). Oak sawdust offered the widest operational window and highest energy metrics; rice straw achieved near-complete carbonization at minimal energy; perilla delivered intermediate performance with rapid carbonization. This tunable framework supports tailored biochar production for fuel, soil amendment, and adsorption or carbon sequestration.

Keywords: *Absolute yield; Agricultural and Forestry Biomass; Biochar production; Energy Efficiency; Microwave Pyrolysis; Response Surface Methodology; Thermochemical Conversion.*

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Efficiency Evaluation of Lead (Pb) and Copper (Cu) Removal from Morna River Water, Akola using Low Cost Agricultural Adsorbent

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Abstract

The water resources issue in India is becoming much severe because of the acceleration of the process of urbanization, increasing population, industrialization, high fertilizers application in agriculture, man-made activity is highly polluted water with different harmful contaminants. In Akola city the municipal wastewaters is directly discharge into Morna River without any treatment and people living on downstream side using the river water for irrigation and drinking purposes. The research was carried out to identify and remove harmful heavy metal such as Pb and Cu through different Low cost Activated carbon prepared from rice husk, corn cob and sugarcane bagasse and the efficiency of removal was calculated. The raw wastewater Sample was collected from mornariver directly in 5 liter LPDE bottle and so that it does not adulterated before it reaches the laboratory. The wastewater samples were collected from Ganesh Ghat on Morna River bank which flow through the Akola city area, the low cost activated carbon form agricultural waste was prepared by adopting standard procedure, the raw material was collected locally. Presence of Pb and Cu in raw wastewater were found 0.27 mg/l and 0.13 mg/l respectively. The filtration unit was set up in such a way that equal amount of raw wastewater passes through three different low cost activated carbon bed. The highest removal of Pb and Cu was found in activated corn cob powder with 79.49 % & 98.93 % respectively removal efficiency in compared with activated rice husk and sugarcane bagasse powder. By using low cost agricultural waste as a source of activated carbon can effectively for filtration of waste as well as potable water.

Keywords: *Activated carbon; Adsorbent; Efficiency; Filtration; Low Cost; Waste Water.*

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Mechanized Strip Cropping pattern for assessing Production Efficiency, Energy Requirement and Yield Attributes cum Economics in Soybean (*Glycine Max* (L) Merill): Pigeon Pea (*Cajanus Cajan* (L.) Millsp) intercropping

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Abstract

Energy requirement and monetary analysis are used to determine energy and economic indices for better crop management and enhancing production. The power necessary for agricultural production is provided by human labour, draught animas and engine-driven machinery. Energy analysis is based on field operations (land preparation, sowing, intercultural, harvesting and residue management) as well as on the direct (fuel and human labour) and indirect (machinery) energy sources involved in the crop production process. A well-managed mechanized strip-intercropping system could result in higher profitability and helps towards minimizing energy requirement. Therefore, a field experiment was conducted to study response of Soybean (*Glycine max* (L) Merill): Pigeon pea (*Cajanus cajan* (L.) Millsp) strip cropping on growth, yield, energy management and cultivation economics under mechanized practices at experimental farm of All India Coordinated Research Project on Dryland Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India during *kharif* seasons of 2018-19 and 2019-20. The experiments were laid out in randomized block design with eight treatments *i.e.* T_1 -soybean : pigeon pea strip of 6:3 rows ,T_2 - soybean : pigeon pea strip of 6:6 rows, T_3 - soybean : pigeon pea strip of 12:9 rows,T_4 - soybean : pigeon pea strip of 12:12 rows , T_5 - soybean : pigeon pea strip of 18:12 rows ,T_6 - soybean + pigeon pea (4:2) intercropping system, T_7 - sole soybean and T_8 - sole pigeon pea replicated thrice. The energy requirements (MJha-1) of each treatment in which tractor operated seed cum fertilizer drill was used for sowing soybean: Pigeon intercropping were determined and analyzed. The data on yield and yield parameters, energy requirement and crop production economics was collected at periodical intervals and analyzed. Based on pooled results of two year data, the energy consumption rate was found less in solo cropping of Pigeon Pea sowing and highest in solo crop sowing of soybean crop. The energy consumption rate was found highest in T_7 as more direct and indirect energy is evolved due to higher consumption of operational time of seed drill and fuel. The energy requirement of treatment T_4 and T_5 was found nearly same along with good results of crop yield attributes in same plots. It was found that, among the strip cropping treatments, T_5- soybean : pigeon pea strip of 18:12 rows recorded highest soybean equivalent yield, Minimum energy requirement, maximum gross monetary returns and net monetary returns and was at par within treatment T_4 - Soybean: pigeon pea strip of 12:12 rows.

Keywords: *Economics; Efficiencies; Energy Requirement; Seed cum Fertilizer Drill; Soybean Equivalent yield; Yield Advantage Indices; Strip Cropping.*

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Paper No.: IAEC 2025- REE – 10

Investigation of Landsat Image to Detect Snow Cover, Debris Cover and Clean Ice Glacier Cover in Nepal (In Koshi, Gandaki and Karnali basin)

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Abstract

Nepal is a mountainous country with majority of the area covered by mountains and hills. Glaciers of the Himalayas are storehouse of fresh water from which hundreds of millions of people downstream benefit, when needed in dry season. These Himalayas are also termed as the “water tower” and “third pole” of the earth. It was documented that there are 3,252 glaciers in Nepal alone. Area of 5,324 square kilometers is covered with high frozen reservoirs that release their water at the top of their watershed (Pradeep.K, et al. 2001). Generally, the area higher than 4,000 meter above mean sea level is covered by snow and ice throughout the year. Mountains are particularly vulnerable to climate change. The impacts of climate change, mainly melting of snow cover have been noticed in Nepalese Himalayas. Temperature rise between 0.15 and 0.6 degree per decade is recorded in Nepal. Increased snow and glacial melt and frequency of extreme weather have exacerbated livelihood risks including poverty, food insecurity, hazards and social inequity. The country is vulnerable to various hazards due to fragile geological conditions, active tectonics rich diversity of climates, hydrology, ecology and great elevation differences and steeply sloping terrain. Apart from the landslides and river erosion, this region is quite susceptible to hazards due to glacial lake outburst floods (GLOFs). The objective of this research is to investigate the Landsat satellite images for the detection of change of Snow-covered area and area of DC and CI Glaciers of Nepal for years 2000, 2002 and 2003. The three major basins (Koshi, Gandaki and Karnali Basin) of Nepal have been studied in this research. The methods used in ERDAS and Arc GIS are based on methods used in past studies, our own hit and trial, and guided by software guidebooks. The snow cover area delineation and zonal change detection by image difference is done by using the NDSI Model Method. These outputs were exported in GIS for calculation of snow-covered area and image differences of two time periods. The results of area corresponding to the snow cover, clean and debris covered glacier is obtained using Arc GIS and Ms Excel. Snow cover area, Debris covered area, Clean Ice Glacier area and Zonal change detection of Nepal have been delineated using Landsat images and different software like ERDAS, Arc GIS.

Keywords: *Glaciers; Storehouse; Debris; Vulnerable; Climate.*

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Paper No.: IAEC 2025- REE – 11

Solar Irrigation for Sustainability of Paddy Production and Gender Empowerment

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Abstract

Rice is a staple food globally, and increasing demand requires an additional 100 million tons of paddy annually. In Nepal and South Asia, rice is crucial for food security and the economy. However, it demands significant water, especially during monsoon and spring seasons. To boost domestic production and reduce imports, the Government of Nepal has prioritized rice cultivation in these two seasons.

This study examines the impact of solar irrigation on sustainable paddy production and gender empowerment in Kachankawal Rural Municipality, Jhapa. It uses 25 years (1999 – 2023) of climate data specifically rainfall and temperature to assess irrigation needs and analyzes whether solar irrigation systems meet crop water requirements. A mixed-method case study approach was used, combining climate and crop data with participatory tools to understand the perspectives of farmers, especially women.

The study finds a decreasing trend in annual rainfall (4.9 mm/year) and temperature (0.0285° C/year), though these are statistically insignificant. From 2017 to 2023, crop water requirements decreased for monsoon rice and increased for spring rice. Water balance analysis showed surplus water for spring rice but deficits for monsoon rice in some years, indicating a need for better seasonal water planning.

Solar irrigation has significantly improved rice productivity, reduced fossil fuel dependency, and cut carbon emissions saving about 36.66 metric tons of CO_2 annually (249.8 kg CO_2/ha). It also contributed to gender empowerment by easing women's workload, enhancing their role in decision-making, and promoting inclusion in water management.

Despite positive outcomes, challenges like high installation costs, limited financial access, and moderate gender disparities remain. Addressing these through inclusive policies, financial support, and capacity-building is vital for equitable, sustainable adoption of climate-smart irrigation. Overall, the study highlights solar irrigation's potential to promote sustainable agriculture, climate resilience, and gender equity in rural Nepal.

Keywords: *Solar Irrigation; Paddy Production; Climate Change; Water Requirement; Gender Empowerment; Sustainable Agriculture; Carbon Emission Reduction; Climate-Smart Technology.*

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IAEC – 2025 - SWE - 01

Precision Irrigation Systems Using AI and IoT

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Abstract

Smart irrigation systems encompass those innovative technologies that combine the power of data analytics, automation, and precision for managing water most efficiently. Water resources demands in all sectors including agriculture is increasing. Water scarcity, climate change, soil health, crop yield and quality and energy and cost savings give rise to the question of sustainability in agricultural production. To meet this challenge superior technologies, need to be adopted to increase water productivity in agriculture which is the largest consumer of water. Precision irrigation systems coupled with AI and IoT offer a promising solution for optimizing water use, increasing crop yields, and reducing environmental impact.

Precision irrigation / digital irrigation is a practice of watering crops as per their actual requirements. These systems integrate various technologies to deliver water precisely where and when it is needed, based on real-time data and the specific requirements of the crops. Digital irrigation encompasses various technologies and approaches, each with its unique features and applications. Some of the primary types include drip irrigation, soil moisture sensors, weather-based systems, remote control and automation, subsurface drip irrigation, agricultural weather stations, scheduling systems and aquaponics and hydroponics.

In view of the pressing need for efficient water management in agriculture and the availability of different types of smart irrigation systems mentioned above, farmers can select appropriate type of digital irrigation systems to optimize their crop production while conserving valuable resources. These systems are not only a response to the challenges of modern agriculture but also provide a sustainable solution for ensuring food security. Smart irrigation systems offer a wide range of advantages including water conservation, increased crop yields, cost savings, environmental sustainability and remote monitoring. However initial cost, accuracy of data, technological literacy and infrastructure remain challenges in implementing digital/ smart irrigation on a large scale.

A drip irrigation scheme was initiated in the year 2012 for farmers owning half to one acre land holdings in district Alwar, Rajasthan under Precision Farming Development Centre at Water Technology Centre, IARI, New Delhi. Guidance was provided to these farmers through formal and informal channels. Now the number of farmers benefitted under this scheme has grown more than ten times. Encouraged by the increased incomes several of these farmers have started adopting other technologies including polyhouses, *etc*. The article aims to present this real field case study of farmers' adoption of digital irrigation technologies.

Keywords: *Precision Irrigation System; Technical Guidance; AI and IoT; IARI New Delhi.*

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IAEC – 2025 - SWE - 02

Smart Alternate Wetting and Drying System for Rice Cultivation in Bangladesh

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Abstract

Rice is one of the most water-intensive crops in agriculture, and Bangladesh annually consumes large volumes of water for its cultivation. To address this, Gazipur Agricultural University introduced an automated Alternate Wetting and Drying (AWD) irrigation system. However, the existing system lacks remote operation capabilities and cannot maintain stagnant water during the critical flowering and milking stages of rice growth. This study aimed to develop and evaluate a smart AWD irrigation system for rice cultivation, focusing on its effects on plant growth, yield components, and water use efficiency (WUE). The system integrated an ultrasonic sensor, a water-level-controller PCB, solenoid valves, and water level detection probes to regulate water depth. Additional sensors, including temperature-humidity and rain sensors, were used to collect microclimatic data and monitor rainfall. The system was powered by solar energy for field deployment. The experiment employed a Randomized Complete Block Design (RCBD) with four replications and three treatments: T_1 (Flood Irrigation), T_2 (Conventional AWD), and T_3 (Smart AWD). Results indicated no significant differences in growth and development parameters between T_1 and T_2, nor in yield components across all treatments. Notably, the highest water use efficiency (WUE) of 0.652 kg/m³ was observed in T_3, while the lowest, 0.526 kg/m³, was recorded in T_1. The smart AWD system achieved a 20% reduction in irrigation water use compared to conventional flood irrigation without compromising yield. These findings demonstrate that the smart AWD system offers a sustainable, water-saving solution—particularly during the Boro rice season—that enhances water productivity and supports sustainable rice cultivation in Bangladesh.

Keywords: *AWD; Rice; Smart Irrigation; Water Use Efficiency.*

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IAEC – 2025 - SWE – 03

Hydrological and Water Quality Evaluations at Watershed Scale Using a Modeling Approach

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Abstract

This study contributes how climate variability impact on our water quality, quantity, crop yields, and effectiveness of management practices can be evaluated at watershed scale using computer-based modeling tools such as Soil and Water Assessment Tool (SWAT). The SWAT models were developed using available geospatial and historical or current weather data, and watershed management practices. The model was calibrated and validated using observed hydrological and water quality data such as streamflow, sediment, and nutrients. The SWAT model performances during model calibration and validation of flow, sediment, and nutrient was evaluated using statistical parameters such as coefficient of determination (R^2) and Nash Sutcliffe efficiency (NSE). The findings of this study are believed to be useful to watershed managers and policymakers as they plan to develop “climate resilient agriculture” programs or practices. Additional water quality parameters and their importance to agriculture and environment will be presented with the aim to improve global agro-ecosystems.

Keywords: *Agro-ecosystems; Modeling; Watershed; Water Quality.*

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IAEC – 2025 - SWE – 04

Rice Crop Growth Modelling Using SAR Data through Machine Learning Models

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Abstract

Rice yield prediction has been soar points for optical remote sensing system under over cast condition. The free of cost sentinel 1 based SAR data along with machine learning models through GEE cloud was used for rainfed rice crop monitoring in micro scale for 214 farm plots in Hooghly, West Bengal, India. The violin plot rice parcel showed a low median backscattering signature from the SAR data during the preparation/transplanting crop stages with VH and VV at -17.63 dB and -9.63 dB, respectively, whereas, higher median backscattering was experienced at peak vegetation stage of VH and VV Polarization with -15.20 dB and -6.34 dB, respectively. The random forest model found best suitable with R^2 of 0.87 for total crop biomass estimation. The backscatter values have significant correlation with Heading NDVI and total biomass, which validated the suitability of SAR image for crop monitoring under rainfed condition. Further, crop yield prediction through SAR data using machine learning models showed sound correlation with Random forest, extreme gradient boosting and Decision tree models with Area under receiver operating characteristics curve (AUROC) test accuracy of 0.99. These low cost SAR data models will be used for near real time crop monitoring even under overcast condition in near future.

Keywords: *AUROC; Crop Biomass and Yield; Rainfed Rice; GEE; Sentinel SAR Data; Random Forest.*

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Assessment of Agriculture Practices in Charland Area of the Padma River in Rajshahi, Bangladesh

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Abstract

Agriculture is the keystone of livelihoods in the study area, where fertile sedimentary soils and seasonal river basins offer significant capability for agriculture production. However, the shifting nature of the charland ecosystem-marked by erosion, accretion, and irregular river flows-makes agriculture practices both diverse and difficult. This research indicates the agricultural practices implemented by peoples in the charland area, targeting on cropping patterns, resource utilization, land preparation, irrigation system, and use of local wisdom. On the basis of primary data collected through household survey with a structured questionnaire, focus group discussion, key informant interview and field observations, after all secondary sources, the study reveals that farmers commonly cultivate Boro rice, wheat, jute, mustard, sesame, tomato, lentil, black gram, pea, grass pea and different vegetables using traditional methods. All respondents (100%) rely on chemical fertilizers and market purchased seeds which are more than substandard and adulterated on account of limited access to modern opportunity. Monsoon flooding, riverbank erosion, poor soil quality, lack of modern irrigation systems was identified significant challenges to productivity. About three-fourths (75.90%) farmers did not get fair price due to poor access to market facilities. All (100%) farmers used pesticides and it has become progressively frequent in response to pest pressures, if its application often lacks research-based advice. Lack of training, limited advisory services, and unawareness of safe pesticide handling contribute to risks for both human health and the environment. The findings highlight the need for targeted initiative in capacity-building services, infrastructure upgrading, and climate-resilient agriculture to ensure the sustainable livelihood strategies of charland people of Padma River.

Keywords: *Charland; Crop Cultivation; Padmavathi River.*

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Biosorption of Copper by *Saccharomyces cerevisiae*: Optimization, Metal Recovery, and Model-Based Process Prediction

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Abstract

Copper ($Cu^{2?}$) contamination from industrial sources such as electroplating effluents poses a serious environmental and public health concern. Traditional chemical treatments for copper removal are often costly and generate secondary pollutants. This study explores the use of Saccharomyces cerevisiae, a cost-effective and environmentally friendly biosorbent, for the removal of copper ions from electroplating wastewater. The objectives were to optimize key process parameters, develop a predictive model for biosorption efficiency, and evaluate the potential for copper recovery and biosorbent reuse. Batch biosorption experiments were conducted to optimize operational parameters, including pH, contact time, biomass dosage, and agitation speed. The removal efficiency of $Cu^{2?}$ ions by Saccharomyces cerevisiae was assessed under various conditions. Additionally, a second-degree nonlinear regression model was constructed to predict biosorption performance. Desorption experiments were performed using dilute hydrochloric acid to assess the reversibility of copper binding and the reusability of the biosorbent. The optimal conditions for maximum copper removal (98.4%) were identified as pH 6.0, biomass dosage of 5.0 g/L, contact time of 120 minutes, and agitation speed of 200 rpm. pH was a critical factor, with removal efficiency increasing to 86.5% at pH 6.0, attributed to the ionization of yeast surface functional groups such as carboxyl, amino, and hydroxyl, which interact with $Cu^{2?}$ through electrostatic attraction, complexation, and hydrogen bonding. Copper removal efficiency improved with contact time, reaching 90.7% at 120 minutes, after which equilibrium was attained. Biomass dosage also enhanced removal up to 95.6% at 5.0 g/L; further increases led to a slight decline due to possible particle aggregation. The regression model showed high predictive accuracy ($R^2 = 0.9882$), with pH and biomass dosage being the most influential variables. Copper recovery from the biosorbent using dilute HCl was effective, with desorption efficiencies ranging from 85.7% to 88.4%, confirming the reversible nature of copper binding. This study confirms that Saccharomyces cerevisiae is a highly effective and economical biosorbent for copper removal from electroplating wastewater. The optimized conditions and predictive model support the development of sustainable and scalable treatment processes. The high recovery efficiency also demonstrates the feasibility of biosorbent regeneration, offering a promising approach for metal remediation in industrial wastewater management.

Keywords: *Biosorption Model; Copper Removal; Metal Contamination; Regeneration Process; Saccharomyces cerevisiae; Wastewater Treatment*

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Spatiotemporal Mapping of Irrigation Requirements for Green Gram in Marathwada Region of Maharashtra, India Using Geospatial Techniques

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Abstract

Despite the crucial role of water in agricultural production, exact estimates of water requirements of field crops are often lacking in many regions of India. This study focuses on estimating crop water needs accurately and exploring spatio-temporal variability of crop evapotranspiration (ET_c) for green gram crop in Marathwada region of Maharashtra, India. The modified Penman-Monteith method was used for estimating ET_c using 32-year (1990-2021) daily weather data across eight districts of Marathwada. Results revealed that the ET_c of green gram in the region increased slightly from 1st crop week (2.3 mm per day) to 3rd crop week (2.4 mm per day). Thereafter, the ET_c increased in 7th crop week to 4.3 mm per day and remained constant during mid-season stage, and later on, it gradually decreased to 2.2 mm per day at the end season (11th crop week). The average daily ET_c of green gram was 3.8 mm per day over the entire growing season. Among the different districts, seasonal ET_c ranged from 280 mm (Dharashiv district) to 240 mm (Hingoli district). Geographical variations exhibited the higher ET_c in southwest and some area of southeast portion of the region, while the northwest portion displayed the lower ET_c values. Mann-Kendall test indicated significantly decreasing trends in ET_c of green gram mainly during two crop weeks, i.e., 9 and 10, across most of the districts, which was further confirmed by the results of Sen's slope estimator. Farmers in the study area can schedule the application of irrigation for green gram at right time and in appropriate amounts depending upon the specific ET_c values. Thus, findings of this study are useful to farmers and agriculture department by enabling optimized irrigation water management.

Keywords: *Crop coefficient; Crop water requirement; Irrigation water management; Mann-Kendall test; Penman-Monteith method; Sen's slope estimator; Spatio-temporal Variations.*

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Application of Artificial Neural Network Techniques for Estimation of Evapotranspiration

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Abstract

Estimation of evapotranspiration and future needs of water requirement in agriculture is becoming critical under changing climate. The location specific data on climatic parameters required for estimation of evapotranspiration is usually not available in India. Hence, a study is undertaken to estimate the reference evapotranspiration (ETo) with minimum weather parameters for historical weather data of 42 years for Aurangabad and compared with estimates obtained using well-established FAO Penman-Monteith method. The climate based estimation methods used in the study include Hargreaves-Samani, FAO 24- E-Pan, Priestly Taylor and Turc. The different Artificial Neural Network architectures were formulated using combinations of input climatic variables and were trained using Neural Network tool of MATLAB software. Performances of these methods were evaluated using various statistical parameters viz., mean absolute error, mean standard error, root mean square error, and coefficient of determination, coefficient of correlation and the model efficiency. Results revealed that when all climatic data is available, FAO Penman-Monteith method is the best indirect method if all data on all climatic variables is available. The ANN Model-B with architecture 3-9-1 and inputs parameters minimum and maximum air temperature, and wind speed recorded accurate estimates of daily ETo followed by ANN Model-A with architecture 2-11-1 (input parameters minimum and maximum air temperature). ANN Model- B recorded better model efficiency (99%) and lower MAE (0.0324) as compare ANN Model-A. The minimal input of climatic parameters, ANN Model-B and ANN Model-A estimated more accurately ETo for Aurangabad when data pertaining to climatic parameters is insufficient to apply standard ETo estimation methods.

Keywords: *Artificial Neural Network; Aurangabad; Evapotranspiration; FAO Penman-Monteith method.*

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Methodology to Design and Operate Multi - Crop Integrated Farms

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Abstract

With the size of landholdings continuously decreasing, ensuring household-level income and food security on limited land for farmers is a pressing challenge. This product presentation introduces a standardized farm design methodology for planning and implementing integrated farming. This methodology relies on a custom designed digital tool suite: A Crop Calendar Design Software that plans sowing and harvesting time and area allocation per crop, a Farm Mapping Software for design of farms, and a Farm Tracker that records crop growth, input use, and operational tasks. The methodology combines cultivation of grains and pulses (rice, wheat, lentils), vegetables (leafy greens, roots, gourds), fruits (banana, guava, citrus), oilseeds and nuts (mustard, groundnut), and spices and herbs (ginger, coriander, basil), and optional small-scale dairy or poultry. Early case studies in Delhi and Nagpur indicate improvements in dietary diversity, soil health, and farmer resilience. Using this framework, small and marginal farmers can allocate just 0.5 acre of their land to achieve household self-sufficiency for a family of 4. With their family's nutritional needs secured, farmers are then free to use the remaining land for income-oriented agricultural activities. In the full product presentation, this methodology will be demonstrated through the operation of First Harvest's digital tools, showing how crop planning, farm mapping, and operational tracking come together to make permaculture and integrated farming practical and scalable for all sizes of landholding.

Keywords: *Crop Calendar; Farm Mapping; Methodology; Multi-crop Integrated Farms.*

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IAEC – 2025 - SWE – 10

Intelligent Crop Health Monitoring and Early Disease Detection System Using Deep Learning Models

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Abstract

Plant diseases and inefficient resource use threaten global food security. This paper presents an integrated AI–IoT–remote sensing platform designed for smart crop disease monitoring and early detection. The system combines UAV-based multispectral imaging with real-time IoT sensor data in a centralized analytics pipeline. Data are pre-processed and analyzed using an optimized deep learning model, YOLOv11, enhanced with transformer-based attention mechanisms, achieving over 97% detection accuracy and 92.7% recall for small lesions. Beyond detection, the approach introduces a holistic Composite Health Index (CHI), integrating predictions with vegetation indices (NDVI, EVI), morphological, and texture features to provide real-time crop health assessments. The system is deployed through a hybrid edge cloud infrastructure, enabling low-latency inference on edge devices like the Jetson Nano (5–7 FPS) for field use, supported by cloud-based large-scale processing. Results are delivered via intuitive mobile and web dashboards featuring health heatmaps and multilingual voice alerts. Field trials demonstrated the platform's effectiveness, reducing pesticide use by 26%, improving scouting efficiency threefold, and lowering yield loss by 32%. Despite challenges such as limited data for rare diseases and adoption barriers, this research highlights the transformative potential of integrating advanced technologies to enable proactive, sustainable agriculture and strengthen global food security.

Keywords: *Crop Health, Disease Detection, Deep Learning Models, Delhi and Nagpur.*

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Next-Generation Precision Vertical Hydroponics in Protected Cultivation: IoT and AI-Driven Climate Resilient Agriculture

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Abstract

Agriculture is the most important economic sector that contributes to a nation's global economic prosperity. The increasing population growth and urbanization in Indian cities, along with the climate change & reduction in agricultural land, have driven interest in controlled environment based soilless farming as an alternative farming technology to promote food security and urban sustainability. Additionally, the Sustainable Development Goals (SDGs) aim to achieve zero hunger and sustainable agriculture by 2030. With a simultaneous decline in cultivable land and water scarcity, food production must increase to achieve the above mission. Vertical farming is an advanced, state-of-the-art agricultural technology that boosts crop yield per unit area. Research work involves designing and developing an IoT-enabled smart vertical farming system with a controlled environment for crop growth. This technique utilizes the NFT vertical hydroponic system, along with various sensors and a pH, EC, water level, and water temperature monitoring system. This paper presents a comparative analysis of an IoT-based controlled environment vertical farming system versus an uncontrolled system for Romaine lettuce, examining plant growth parameters (including plant height, leaf count, leaf area, root length, NDVI, and crop yield), phytosynthetic behavior, and quality parameters. Results showed that the IoT-based system significantly outperformed the manual setup, delivering a 22% increase in yield, earlier crop maturity, reduced growing duration, enhanced vegetative growth, improved photosynthetic efficiency, superior quality parameters, and a 20% improvement in water use efficiency. Over the long term, the automated system promises higher consistency, scalability, and reduced labour dependence for commercial hydroponic operations. Its precision-driven, data-centric approach supports sustainable crop management and makes it well-suited for continuous use in modern climate resilient farming systems.

Keywords: *Artificial Intelligence (AI); Internet of Things (IoT); Protected Cultivation; Smart Nutrient Monitoring; Vertical Farming.*

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Paper No.: IAEC 2025- SWE – 12

Simulation of Climate Change Impacts on Specific Wheat Varieties Yield and Potential Adaptation Strategies Using The DSSAT in Central-Southern Region of Nepal

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Abstract

Simulation models, including the DSSAT (Decision Support System for Agro technology Transfer) CERES models, are frequently employed to describe, develop, and evaluate agricultural practices for field crops across various climatic conditions in arid and semi-arid areas worldwide. Grasping the relationship between crop yields, irrigation frequencies, and fertilizer applications is a critical aspect of region-specific agricultural methods. Wheat is the most extensively cultivated crop globally and a vital irrigation dependent staple in Terai, Nepal. This research focuses on the calibration, validation, and application of the DSSAT-CERES model for wheat cultivation in the semi-arid sections of Eastern Terai, Nepal. Twelve treatment combinations, each replicated four times, consisted of four levels of nitrogen fertilizer (0%, 50%, 100%, and 125% of the recommended dose) paired with three irrigation frequencies (15, 21, and 25 days post-sowing) across three consecutive years (2022-23, 2023-24, and 2024-25). Crop responses were monitored during different growth stages (Tillering initiation at 20 days, Booting initiation at 40 days, and Anthesis initiation at 60 days). The results indicated that higher irrigation frequencies and greater fertilizer rates significantly boosted crop growth and yields. The values of observed and simulated yields from three years of wheat crop development demonstrated a strong correlation, with d-index values of (0.65 in 2022-23, 0.82 in 2023-24, and 0.91 for 2024-25), indicating that the model was effectively calibrated against observed data. The findings suggest that DSSAT can accurately simulate plant growth, yield, and development at the experimental site. An examination of climate change impacts on yield was conducted using the calibrated DSSAT-CERES Wheat model. Future wheat yields were projected for both RCP 4.5 and RCP 8.5 scenarios for the periods 2021-2050 and 2051-2080. The DSSAT model can also assist in determining optimal sowing dates for prospective climate change scenarios. In the RCP 4.5 scenario, all treatments displayed negative yield outcomes; however, treatment T-2 was beneficial for seeding with lower plant density, while all treatments in the RCP 8.5 scenario showed negative yields compared to historical data. This suggests a potential yield increase with earlier sowing dates, a trend observed for both one-week and two-week early sowing dates.

Keywords: *DSSAT-CERES; Wheat; Simulation; Climate Change; Nepal.*

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Assessing Climate Change Effects on Water Balance Components in the Indrawati River Basin Using CMIP6 Projections

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Abstract

This paper assesses the status of water balance of the Indrawati Basin, Nepal due to climate change, using the SWAT (Soil and Water Assessment Tool) integrated with CMIP6 climate projections. The objectives were to calibrate the SWAT model for simulating hydrological scenarios, project future water balance components under SSP2-4.5 and SSP5-8.5 with moderate and high emissions scenarios respectively, and analyze spatial-temporal variations in hydrological procedures. The SWAT model was regulated (2009–2014) and authenticated (2015–2019) using experiential stream flow data, achieving satisfactory performance (NSE=0.7, R^2=0.71). Future climate projections indicated temperature increases of 2–6°C by 2100, with precipitation rising by 9.7% (SSP2-4.5) and 35.3% (SSP5-8.5). Key components subjected to water balance revealed significant changes: under SSP5-8.5, percolation surged by 21%, groundwater discharge increased by 21.8%, and surface runoff rose by 70%, heightening flood risks in southern sub basins. Spatial analysis highlighted stark north-south disparities, with southern regions experiencing higher evapotranspiration (up to 443.5 mm) and runoff compared to the north. These findings underscore the vulnerability of mountainous basins to climate-induced shifts in hydrological cycles. The study emphasizes the urgency of adaptive approaches on water management, upgraded irrigation practices, and flood mitigation measures in Nepal's climate-sensitive regions. Linking CMIP6 data with SWAT modeling, it provides critical insights for policymakers to enhance resilience against climate variability, ensuring sustainable water resource management and food security in transboundary Himalayan basins.

Keywords: *Climate Change; Water Balance; CMIP6; SWAT; Indrawati Basin.*

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Paper No.: IAEC 2025- SWE – 14

Indigenous Agricultural Practices Adapted in Drought Area of Mahottari District of Nepal

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Abstract

This study explores the indigenous technologies and traditional knowledge systems employed by farmers to enhance drought resistance in agriculture. Indigenous practices, rooted in centuries of adaptation to local environmental conditions, offer sustainable and cost-effective solutions to water scarcity and crop resilience. These technologies include water conservation methods such as mulching, soil moisture retention techniques and the use of drought-tolerant native crop varieties (Eg: Sukkha-3, Rice variety). The investigation highlights the role of community knowledge sharing and adaptive strategies in mitigating the impacts of drought on agricultural productivity. Agriculture practices like Daicha cultivation, Apiculture, Yam cultivation, oilseed crops (flaxseed, Sesame, Saff flower), legumes crops (Pigeon pea, Mung bean, Chickpea) are commonly adapted by farmers in Mahottari. The findings underscore the importance of integrating indigenous technologies with modern agricultural practices to develop climate resilient farming systems that ensure food security under changing climatic conditions. This research contributes to the recognition and promotion of indigenous innovations as vital components in the global effort to combat drought and sustain rural livelihoods.

Keywords: *Indigenous Agricultural Practices; Drought Tolerant; Food Security; Develop Climate Resilient.*

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Paper No.: IAEC 2025- SWE – 15

Enhancing productivity of Rainfed Agriculture through climate resilient technologies-Experiences from Maharashtra

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Abstract

The global rainfed area is estimated to be around 1.1 to 1.5 billion hectares (Bha), with one study placing the rainfed cropland area at approximately 1.2 billion hectares or 80% of the world's total cropland, a figure that aligns with the observation that 60% of the world's food comes from these areas. These regions are most prominent in Asia, Europe, and North America and are critical for food production, especially in developing nations.

Rainfed agro-ecosystems occupy a significant place in Indian agriculture. Out of 141 million ha of net sown area in the country, 80 million ha. area is rainfed and will remain same for a foreseeable future. In Marathwada region, out total cultivated area of 57.94 lakh ha, 49.60 lakh ha area is rainfed. The impact of climate change and variability in the country on agricultural production is quite evident in the recent years. Climate change threatens the sustainability of present agriculture as well as small and marginal farmers. Sustainable crop production requires plant type that are more productive, efficient user of nutrients and water, have greater resistance to insect, pest and diseases and are more tolerant to climatic extremities Viz. drought, flood, frost and high temperature. The probability of erratic monsoon rains is about 40% which implies that 4 out of 10 years there would be an adverse impact on the crop production. There is need to develop appropriate strategies to deal with such eventualities. Many contingency plans are available at different scales. However, any contingency intervention either technology related (land, water, soil, crop) or institutional and policy based, which are implemented on a real time basis in any crop growing season considered as “Real Time Contingency Plan” is the need of hour to stabilize crop stands, production and income in rainfed regions.

The weather aberrations like drought and floods, extreme events like high intense rainfall, hail storms, heat wave, cold wave etc. are recurrent in most parts of the country during the crop growing periods. The South-West monsoon account for nearly 75% of the precipitation received in the country and exerts a strong influence on the *kharif* food grain production and the economy in terms of agricultural output, farmers income and price stability. The onset of South west monsoon, the amount of rainfall and its distribution. The impact of climate change and variability in the country on agricultural production is quite evident in the recent years. Looking to the occurrence of frequent dry spells and drought, the stress management practice like spraying of KNO_3 was found effective under dryspell. BBF sowing method for major crops like soybean, cotton and pigeonpea. Insitu and exsitu rain water harvesting, efficient use of stored water, Conservation furrow, intercropping system performed better in terms of enhancing production and profitability in rainfed agriculture.

Keywords: *Climate Resilient: Enhancing Productivity; Rainfed Agriculture; Technologies.*

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Precision-based Fertigation Strategies for Cluster Bean under Semi-arid Tropics of Maharashtra

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Abstract

A field experiment was conducted on cluster bean at the research farm of the All India Coordinated Research Project on Irrigation Water Management, VNMKV, Parbhani. A split-plot design with three replications was used in study. Drip irrigation method with every alternate day was adopted for all the plots with five different irrigation levels as main plot *viz*., 0.4 ETc (I_1), 0.6 ETc (I_2), 0.8 ETc (I_3), 1.0 ETc (I_4) and Farmer practice (I_5). Fertigation levels were Control (F_1), 50% (F_2), 75% (F_3) and 100% (F_4) of recommended dose of fertilizers (40:60:60 NPK kg ha^{-1}) with six splits during crop growth period. Among the various irrigation levels considered, irrigation treatment I_4 (drip irrigation with a 1.0 ETc), showed significantly superior cluster bean growth attributes. It is also observed that I_4 (drip irrigation with 1.0 ETc) was comparable with irrigation schedule I_3 (drip irrigation with 0.8 ETc). In case of fertigation, the application of fertilizers at 100% recommended dose of fertilizer (F4) showed significantly superior growth characteristics of cluster beans, which were comparable with the fertilizers which applied at 75% RDF (F3).The drip irrigation scheduled at 0.8 ETc on alternate day and application of drip fertigation @ 30:45:45 NPK kg ha^{-1} was found to be both productive and profitable with saving of 20 % water and 25% fertilizers, respectively.

Key words: *Cluster bean; Fertigation; Growth Characteristics; NPK.*

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Paper No.: IAEC 2025- AM-01

Innovative Mechanisms for Financing Agri-Food Exports: Case Study of the Republic of Uzbekistan

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Abstract

This research aims to identify and systematize effective mechanisms for financing agri-food exports, with a special focus on the Republic of Karakalpakstan. The study analyzes the current landscape of food exports, evaluates existing financial instruments, and proposes innovative approaches to enhance export financing. Drawing on both local and international experiences, the research highlights key barriers and opportunities in developing a robust export financing framework for the region. The findings provide practical recommendations for policymakers and stakeholders to improve the efficiency, resilience, and sustainability of food exports from Karakalpakstan, thereby contributing to regional economic development and food security.

Keywords: *Agri-food exports; Export financing; Innovative mechanisms Karakalpakstan economy; Sustainable agriculture.*

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Design and Test of Tractor-Mounted Peanut Digger for Five-Row Peanut Cultivation

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Abstract

Five-row peanut planting system is increasingly adopted in Thailand because of its potential to enhance yields compared to traditional single or double row systems. However, the harvesting process for five-row cultivation of peanut is challenged, particularly in labor intensity. This article presents the design and testing of a tractor-mounted peanut digger developed for five-row peanut plantations. The prototype was designed using the Finite Element Method (FEM) to simulate the structural strength of both the digging blades and the main frame. Two types of digging blades as Blade Model 1 and Blade Model 2 were analysed. The results indicated that Blade Model 2 exhibited lower stress levels and a higher safety factor compared to Blade Model 1. Consequently, Blade Model 2 was selected for prototype fabrication and field testing. The prototype was designed to be mounted on a four-wheel tractor with a 95-horsepower engine. The important components of the digger consisted of the main frame, digging legs, digging blades, and soil and weed cutting discs. Field performance testing involved dividing the planting rows into three sections and counting the number of dug peanut plants within a 1.69 m² square frame to evaluate digging efficiency. The result was found that the prototype achieved a digging efficiency of 90.7% and an effective field capacity of 5.44 hector per day.

Keywords: *Peanut; Digger; Finite element method.*

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Theoretical Justification of the Kinematics of a Blade Rotational Drum

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Abstract

This study investigates the kinematics of the rotary drum blade under controlled conditions, focusing on the trajectory of motion and energy efficiency in soil tillage. Equations of motion were developed to calculate the drum center's trajectory and blade paths under varying rotational parameters, considering angular velocity, rotation radius, and cycloidal motion types. Classical numerical methods were employed to model technological processes in rotary tillage machines, drawing on Panov I.M.'s theoretical developments in energy-efficient soil loosening. The analysis revealed that passive working bodies in soil tillage machines influence soil compaction and deformation based on their geometric shape and operational speed. The trajectory of the drum blades follows cycloidal motion, which varies with speed, forming elongated or shortened cycloids. Mathematical modelling demonstrated that optimal energy consumption occurs during tensile deformation of the soil, minimizing resistance while ensuring effective soil loosening. Furthermore, the study confirmed that rotary tillage machines significantly reduce traction resistance and energy consumption while improving soil aeration and weed removal. The research highlights the advantages of optimizing drum rotational parameters and blade design for maximum efficiency. Compared to traditional tillage methods, rotary tillage machines with active rotary drums offer superior energy efficiency and soil processing quality. The findings emphasize the importance of cycloidal motion in minimizing energy consumption while maximizing soil loosening. Future research should focus on optimizing blade configurations and rotational parameters to enhance performance. Conducting field experiments will be crucial for validating theoretical predictions under real agricultural conditions.

Keywords: *Blade kinematics; Rotational drum; Theoretical analysis; Mechanism design.*

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Paper No.: IAEC 2025- AM-04

Analysis and Improvement of the Materials of the Soil-Cultivating Plowshare.

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Abstract

Uzbekistan is considered one of the hottest countries among the Central Asian nations, and a large portion of its land consists of arid areas. However, it has several favourable conditions for the efficient use of land in agriculture. As we know, with the arrival of spring, our farmers begin intensive soil cultivation. They strive to use agricultural machinery effectively for softening the soil, levelling it, and completing all pre-sowing work. These agricultural machines are thus the main working tools of our farmers, and their continuous operability, long-lasting performance, and high productivity not only contribute to farmers' income but also naturally help ease hard labour. The main goal of this study is to identify the structural and mechanical properties of the working part of the soil-cultivating plow for Uzbekistan's agricultural machinery industry, and to apply an optimal heat treatment mode to improve its technical characteristics in the engineering sector. The focus is on enhancing and improving the mechanical properties of the internal part of the soil-cultivating plow, specifically the plowshare (lemex), used in agricultural machinery.

Keywords: *Plowshare material analysis; Soil-engaging tools; Wear resistance improvement.*

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Paper No.: IAEC 2025- AM- 05

Selecting the Rotor Shape of a Combined Tillage Machine

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Abstract

The article presents some results of research on the development of a combined tillage machine equipped with a new rotor with a distinctive design from the known rotors. Its advantages in comparison with the known rotor designs are shown. On the developed rotor, each knife during operation describes an individual trajectory of movement, which are offset relative to each other by an equal distance, determined based on the quality requirement of tillage, and as a result, each rotor knife processes a certain area that is parallel offset from the area treated by the previous knife. Initial laboratory tests were done at a depth of 8-10cm, in soil with a moisture content of 12-15 percent and bulk density of1.2-1.4 g/cm 3. The findings demonstrated the decrease to less than 6% of the proportion of soil clods larger than 50 mm, and fuel consumption was decreased by 8-10%, and the index of soil surface evenness was improved by 18% using the proposed rotor compared with conventional rotors. The paper also substantiates the rational values of the radius of the rotor and the length of its blade.

Keywords: *Combined machine; Knife length; Knife; Movement path; Rotor; Rotor radius.*

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Some Physical Properties of 4 Manure Types Sold in Prachinburi

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Abstract

Some physical properties of four types of manure: laying chicken manure, broiler manure, beef cattle manure, and dairy cattle manure, have been studied. Each type of manure was prepared at four levels of moisture content i.e., 10, 20, 30, and 40%wb. The results showed that: the appearance bulk density tends to increase with increasing moisture content. The angle of friction was independent of moisture content on all surfaces. The angle of repose of all manure varies significantly with moisture content. The centrifugal dispersion behavior of each type of manure was different, but the distribution pattern of the same type of manure was not different when the moisture level was increased.

Keywords: *Chicken manure; Layer manure; Beef cattle manure; Dairy manure; Physical properties.*

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Paper No.: IAEC 2025- AS-01

The Preliminary Study of Non-Chemical Weed Control for Precision Agriculture by Heated Vegetable Oil

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Abstract

This research aims to improve the technique for non-chemical weed control by applying heated vegetable oil. Two temperatures of Palm oil, at 50 oC and 70 oC, were applied in this experiment to transfer heat energy to the weed. Two weed cultivars with Spanish needle (Bidens pilosa) and Crowfoot grass (Dactyloctenium aegyptium) at two early phenological growth stages (BBCH 10 and 12) were investigated for the efficacy of weed control. The 1 ml hot vegetable oil was dropped on the weeds. After application, the weeds were cultivated in the natural environment and evaluated the deterioration of weed in a laboratory. Damage to weeds after the treatment was visually assessed every other day for a week. The result demonstrates that a thermal weed control by vegetable oil can be performed as an alternative technique for non-chemical weed control. The type of weed between monocotyledons and dicotyledons affects the efficiency of weed control as well as the phenological growth stage of weed. Applying the 1 ml vegetable oil of 50 oC can be used for weed control with Spanish needle at BBCH 10 in 7 days after application.

Keywords: *Non-chemical weed control; Thermal weed control;Vegetable oil.*

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Paper No.: IAEC 2025- AS-02

Impact of Drop Irrigation and Hand-Dug Wells on Smallholder Farmers' Agricultural Output and livelihoods in Haramaya, Ethiopia

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Abstract

Water scarcity, exacerbated by extended droughts, overexploitation, and inadequate management, is a serious and growing concern throughout Africa. In response, research in Haramaya, Ethiopia, looked at the effects of integrating drip irrigation with hand-dug wells on smallholder farmers' agricultural productivity and livelihoods across two cropping seasons. The study sought to examine increases in agricultural water productivity and overall production, as well as farmers' attitudes toward this novel technology. The research initiative worked closely with smallholder communities in three kebeles in Haramaya Woreda, gathering data from both pilot and non-pilot farmers through interviews, field observations, and exact measurements. The data demonstrated a significant improvement in agricultural productivity for pilot smallholders who used drip irrigation. This method also showed significant water savings, which immediately addressed concerns about overexploitation. A noteworthy societal advantage was the reduction in the burden of manual irrigation, which aided female farmers particularly. Furthermore, the method demonstrated excellent adaptability to a variety of plot sizes. As a result, the study strongly argues for the combined drip irrigation and hand-dug well method as a viable and acceptable solution forsmallholder farmers in Sub-Saharan Africa.

Keywords: *Crop yield; Developing countries; Farmers; Water-efficiency; Water resources.*

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Paper No.: IAEC 2025- AS-03

Science-Based Approaches to Enhancing Public-Private Partnership Mechanisms in Sustainable Agricultural Development: Case of the Republic of Marakalpakstan

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Abstract

This study presents a science-based analysis of public-private partnership (PPP) mechanisms aimed at improving agricultural leasing systems and fostering sustainable agricultural development in the Republic of Karakalpakstan. By examining the current state of agriculture and evolving PPP practices, the research identifies strategic interventions that can enhance the effectiveness of agro-leasing models. Field data collected from local farms and leasing institutions reveal that adopting efficient operational strategies could reduce production costs by up to 20%. Moreover, the integration of innovative technologies has the potential to boost agricultural productivity by 15–20%. These findings highlight the critical role of well-structured PPPs and technological innovation in increasing the efficiency, profitability, and sustainability of the agricultural sector, particularly in ecologically vulnerable and economically underdeveloped regions.

Keywords: *Agriculture; Public-private partnership; Agro-based enterprises; Agricultural leasing; Sustainable development; Food security, Innovation in agribusiness; Karakalpakstan.*

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Paper No.: IAEC 2025- AS-04

Experimental Study of Apricot Drying Using Direct and Indirect Solar Dryers with Natural Convection

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Abstract

This study investigates the drying performance of apricots using direct and indirect solar dryers operating under natural convection. Experimental trials were conducted under field conditions to compare drying time, product surface temperature, moisture reduction, and quality indicators. For reference, open-air sun drying was used as a control. Results showed that apricots dried in the indirect dryer reached equilibrium moisture content in 6 days, compared to 8 days in the direct dryer and 10 days in open-air drying. The product surface temperature in the indirect system was on average 12 °C lower than in the direct dryer, helping preserve the structural integrity of the product. Chemical analysis revealed lower concentrations of toxic elements (0.13 mg/kg vs. 0.22 mg/kg) and nitrate ions (8.5 mg/kg vs. 9.3 mg/kg) in apricots dried in the indirect system compared with open-air drying, resulting in a 10–12% improvement in quality. The findings confirm that indirect solar dryers provide better quality retention and shorter drying times compared with traditional methods.

Keywords: *Solar drying system; Apricot dehydration; Post-harvest technology; Renewable energy in agriculture.*

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Paper No.: IAEC 2025- AS – 05

The Influence of Chlorella Vulgaris on the Productivity of Photosynthesis in Saline Soils and "Afghan Heat"

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Abstract

The paper presents the application of Chlorella vulgaris suspension in extreme conditions of Bukhara ("Afghan heat", saline and desert-arid zones) on the Bukhara-10 cotton variety in various ways, where the studies were conducted at the experimental farm of the Research Institute of Selection, Seed Production, and Agrotechnology of Cotton of the Bukhara Scientific Experimental Station. It was found that the most effective of the studied options was the 4th option, for which Chlorella vulgaris suspensions were used in combination. The aim of the study was to find out how, with what method of application, Chlorella vulgaris suspension has a positive effect on salinity, soil fertility, high temperatures, droughts, yield, and fiber quality. When used together with Chlorella vulgaris suspension (option 4), an increase in the number of cotton bolls from one bush was observed, amounting to 4.0 pcs. more, the weight of one capsule is 1.0 g, the yield increase is -12 c/ha compared to the control. Also, the pH of the medium before application is 8.1, after complex application - 7.5. The presented studies can be concluded that one of the main reasons for the Chlorella suspension containing very valuable components: phosphorus, nitrogen, calcium, potassium, iron, zinc and 40 amino acids, which improves the distribution of nutrients in plants, also on saline soils due to the neutralization of the pH of the environment, as a result of the gradual flow of phosphorus into all plant organs during the vegetation of cotton, which leads to an increase in fruit nutritional elements due to better absorption of elements by the plant than when applying mineral fertilizers, their distribution depending on the leaf surface, accumulation of dry matter, accumulation of crop elements in one plant, photosynthesis productivity amounted to, respectively: 55.20 thousand m2/ha; 275 g/bush; 16 pcs. / bush; and 10.9 g/m2 per day; which is 20.8 thousand m2/ha higher than the control; 131 g/bush; 4 pcs./bush; 1.8 g/m2 per day

Keywords: *Chlorella vulgaris; Photosynthetic productivity; Drip irrigation.*

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Paper No.: IAEC 2025- AS- 06

Design and Development of Mechanized Vertical Farming System

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Abstract

Mechanized Vertical Framing, a sustainable and innovative approach to modern agriculture which enables crop cultivation in limited spaces through stacked layers within controlled environment. The traditional farming techniques cannot alone meet the demand of growing population in an efficient way in limited time. In this smart farming technique, a two-layered hydroponics setup is designed and constructed using PVC pipes, an efficient material that also supports the model design as a basis for structural engineering. Internet of Things (IoT) is integrated for real-time monitoring which incorporates automation and data acquisition controlled via NI LabVIEW. Automation is achieved through sensor feedback and control modules, such as DHT11 and relay-based fans for thermal regulation of 20-25°C, pH sensor maintaining pH between 5.5-6.5 and pump for closed loop nutrient delivery and sponge moisture sensor for moisture content in plants with user interface accessibility through a laptop or mobile device. Upon completion, the setup will deliver a compact, multi-layered PVC framework integrated with IoT-based sensors and a circulation pump. The closed-loop automation enables real-time monitoring and regulation of environmental parameters, ensuring low-maintenance, efficient, and sustainable urban farming suitable for home-scale applications.

Keywords: *Mechanized vertical farming; Hydroponics; PVC; IoT; Automation, NI LabVIEW.*

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Paper No.: IAEC 2025- CEAE-01

Computational Analysis of Thai Plant Diseases: A Preliminary Investigation Based on a Q&A Dataset

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Abstract

Plant diseases pose a significant threat to Thailand's agricultural productivity and food security. This study leverages a domain-specific Thai-language Q&A dataset of 3,000 entries to analyze prevalent plant disease concerns and develop an AI-powered diagnostic assistant. Through fine-tuning a GPT-2 Thai language model (flax-community/gpt2-base-thai), we achieve robust performance with a training loss convergence to 0.20 (97.5% improvement) and evaluation metrics demonstrating high semantic accuracy (0.75 similarity) and linguistic coherence (11.50 perplexity) on a 500-sample test set. Natural Language Processing techniques—including topic modeling and keyword extraction—reveal key insights: (1) fungal diseases in rice dominate farmer inquiries, (2) early symptom identification for durian diseases is frequently misunderstood, and (3) prevention strategies for cassava mosaic virus are under-discussed. The fine-tuned model shows strong alignment with expert knowledge (BLEU score: 0.50) while preserving meaning across paraphrased responses, highlighting its potential for scalable agricultural extension services. This work provides a blueprint for deploying NLP solutions in low-resource languages, emphasizing the value of domain-specific fine-tuning to bridge the gap between technical knowledge and farmer accessibility. Our results advocate for integrating such models into mobile advisory platforms to combat misinformation and strengthen Thailand's plant disease resilience.

Keywords: *Plant Diseases; Thai Agriculture; Q&A Dataset; Natural Language Processing (NLP); Computational Analysis.*

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Paper No.: IAEC 2025- CEAE-02

Integrating UAV-Based RGB Data and Machine Learning for Accurate Assessment of Soil Salinity

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Abstract

Soil salinization poses a significant threat to agricultural productivity and sustainability, particularly in semi-arid regions such as Northeast Thailand. This study investigates the potential of unmanned aerial vehicle (UAV)-based RGB photogrammetry combined with machine learning regression models to estimate surface soil salinity at high spatial resolution. A total of 250 soil samples were collected across two agricultural seasons and analyzed for electrical conductivity (EC) as a proxy for salinity. RGB imagery was acquired using a DJI Mavic Air 1 UAV and processed to generate orthomosaics at four ground sampling distances (GSDs): 5 cm, 25 cm, 50 cm, and 100 cm. From the imagery, seven colorbased indices (GRVI, RGRI, GBRI, RBRI, rn, rg, rb) were computed and used as input features for three machine learning models: Generalized Linear Model (GLM), Random Forest (RF), and Support Vector Regression (SVR). Results showed that RF at 25 cm GSD achieved the highest prediction accuracy (R^2 = 0.68, RMSE = 4.56). The findings underscore the utility of RGB-derived indices and machine learning models in producing cost-effective, scalable, and accurate salinity maps. This approach holds promise for supporting precision agriculture and land management in salt-affected regions.

Keywords: *Soil salinity; UAV; RGB indices; Machine learning; ground sampling distance*

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Paper No.: IAEC 2025- CEAE-03

Implementation of LoRa-Based Remote Monitoring System for Precision Mango Farming.

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2Food Engineering Department, School of Engineering, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand

Abstract

This study investigates the effectiveness of a LoRa-based remote monitoring system in enhancing precision mango farming. The main objective is to evaluate how real-time environmental data collected from soil, air, and light sensors can support improved cultivation practices. A sensor network was deployed in a commercial mango orchard in Chachoengsao, Thailand, focusing on two areas: one managed with good agricultural practices and the other with conventional methods. Ten mango trees were randomly selected from these areas for sensor installation to monitor environmental conditions. Data were collected hourly from July 2023 to April 2024, transmitted to a cloud-based MQTT broker, and visualized through a web dashboard. The study hypothesizes that sensor-guided interventions, such as optimized irrigation and pruning, lead to better environmental conditions and higher fruit yield. Results confirmed that trees under good practices, where the soil retained rainwater effectively, showed higher moisture retention. In contrast, some trees under conventional practices exhibited lower retention. These findings support the potential of IoT-based LoRa systems to enable data-driven, sustainable mango cultivation.

Keywords: *LoRa mango orchard; IoT; Sensors; Monitoring.*

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Golden Ratio-Based Assessment of Nam Dok Mai Mango Shape Using Image Processing

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Abstract

This study presents the application of the golden ratio ($\phi \approx 1.618$) to evaluate the shape aesthetics of the Nam Dok Mai mango variety. Mango shape plays a critical role in determining both market value and consumer preference. However, the assessment of visually appealing mango shapes based on human perception is inherently subjective and susceptible to inconsistency. To address this, the proposed model utilizes one-dimensional (1D) top-view images processed through automated image analysis techniques, including segmentation, contour detection, and feature extraction. Four geometric components (G1, G2, G3, and G4) were derived from the images and statistically analyzed. The results revealed that the computed ratios closely aligned with the golden ratio. The experiment was conducted on a dataset of 100 Nam Dok Mai mango samples. The shapes perceived as visually desirable by human evaluators corresponded closely with those identified by the model as exhibiting golden ratio proportions. Furthermore, for each mango, consistent values of G1 through G4 were obtained from both top A and top B views, confirming the model's repeatability across symmetrical perspectives. This study demonstrates the potential of incorporating mathematical aesthetics, specifically the golden ratio, into agricultural quality assessment frameworks to enhance objectivity and standardization in fruit grading.

Keywords: *LoRa mango orchard; IoT; Sensors; Monitoring.*

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Paper No.: IAEC 2025- CEAE-05

Design and Development of an AI-based LINE Chatbot for Detection and Identification of Major Chili Plant Diseases

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Abstract

This study explores the use of deep learning techniques, particularly variations of the YOLOv11 architecture, for the detection and classification of major diseases in chili plants. Chili is an economically significant crop in Thailand, yet its productivity is often hindered by common foliar diseases. A dataset comprising 7,500 annotated images of three prevalent chili diseases—Cercospora leaf spot, Pepper yellow leaf curl, and Anthracnose—was used to train and evaluate four YOLOv11 variants: YOLOv11n, YOLOv11s, YOLOv11m, and YOLOv11l. Among these, YOLOv11n demonstrated the highest performance, achieving a mean Average Precision (mAP) of 89%. To support real-time disease monitoring in the field, the best-performing model was integrated into a LINE chatbot platform. This AI-powered tool enables rapid and accessible disease identification, thereby enhancing early detection and promoting more effective disease management practices, with the potential to improve crop yields and reduce agricultural losses.

Keywords: *Chili; Image Processing; Deep Learning; YOLO.*

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Paper No.: IAEC 2025- CEAE-06

Development of a Compact Remote-Controlled RC Mower for Thai Agricultural Applications

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Abstract

This paper presents the development of a small remote-controlled RC mower for application in smallholder farming operations in Thailand. Faced with increasing labour shortages and rising costs of operations in the agriculture sector, the foreseen system offers a cost-effective and affordable automation remedy specifically tailored to accommodate the Thai agriculture limitations. The prototype involves a steel light structure, two DC motor-driven wheels, rotary blade motor of high speed, and 2.4 GHz radio frequency remote control. The system draws power from a 12V lead-acid battery with an option to include a solar panel in case of off-grid use. Field tests were carried out in a 10×20 m vegetable farm, where system performance was compared to manual grass-cutting practices. Results indicate that the remote-controlled system saved over 50% cutting time and reduced labour effort considerably, decreasing the cost of operation by over 70%. The design prioritizes ease of use, portability, and flexibility to accommodate narrow or irregular land surfaces predominant in Thai paddy fields. The findings show the potential of low-cost agricultural automation for small-scale farm efficiency improvement. The platform offers a framework for future developments, including semi-autonomous navigation and environmental monitoring, to further improve smart farming in rural Thailand.

Keywords: *Remote-Controlled; RC Mower; Agricultural Applications.*

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Paper No.: IAEC 2025- EE- 01

Utilization of Banana Sheath Agricultural Waste for the Fabrication of Biodegradable Plant Pots

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Abstract

This study aimed at the utilization of banana sheath agricultural waste for the fabrication of biodegradable plant pots. The production incorporated both fibrous and finely ground forms of banana sheath, blended with coconut husk, vermicompost, and starch-based adhesive. A total of 8 formulations were developed: 4 using fibrous banana sheath and 4 using finely ground banana sheath. The mixtures were molded into cylindrical pots using a hydraulic press. The resulting pots were evaluated for their physical and chemical properties to determine their suitability for use. The findings revealed that the fibrous banana sheath pot with a ratio of 3:0:0:2 showed a water disintegration rate of 2.54% and a pH of 7.3, indicating its appropriateness for use in plant display settings. This formulation contained nitrogen, phosphorus, and potassium at concentrations of 0.35%, 0.28%, and 3.76%, respectively. In contrast, the pot made from finely ground banana sheath at a ratio of 2:3:3:12 exhibited a higher water disintegration rate of 13.69% and a pH of 7.73, making it more suitable for direct planting in soil. This formulation had higher nutrient content with nitrogen, phosphorus, and potassium values of 0.83%, 0.53%, and 4.33%, respectively. Furthermore, both types of pots showed good durability, withstanding drop tests from a height of 75 cm without any visible damage.

Keywords: *Banana; Agricultural Waste; Biodegradable.*

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Performance Optimization of Cassava Chip Drying Using Greenhouse-Integrated Hot Air Systems for Industrial Applications

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Abstract

This study aims to optimize the drying performance of cassava chips using a greenhouse-integrated hot air drying system, comparing its effectiveness against natural sun drying and an elevated-floor technique. Experiments were conducted using four chip sizes (2.5 to 4.0 cm) and four drying bed thicknesses (2 to 8 cm). Drying behavior, drying rate, thermal efficiency, and specific energy consumption (SEC) were analyzed at hot air setpoints of 40 °C, 50 °C, and 60 °C. The results indicated that the optimal configuration—chips <2.5 cm with a 2 cm bed thickness at 60 °C—achieved a drying time of 10 h, reducing drying duration by 56.5% and lowering SEC from 9.30 MJ/kg to 4.41 MJ/kg compared to sun drying. The maximum thermal efficiency reached 71.60% under greenhouse-assisted drying. This improvement translates to a 1.36 kWh/kg energy saving and a CO_2 reduction of 0.82 kg per kg of water removed. The system offers a promising energy-efficient and climate-resilient solution for industrial cassava drying in tropical regions.

Keywords: *Cassava chips; Greenhouse dryer; Hot air drying; Specific energy consumption (SEC); Drying kinetics; Thermal efficiency.*

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Paper No.: IAEC 2025- EE-03

Synthesis of Cellulose Fiber from Corn Stover via Alkali/Acid Treatment and Microwave-Assisted Extraction

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Abstract

Corn stover (CS) is an abundant lignocellulosic byproduct of corn processing and is a promising source of cellulose fiber. Its chemical composition was determined using the Van Soest method and Klason lignin analysis, revealing 21.3% cellulose, 23.1% hemicellulose, 13.7% lignin, and 4.6% ash. To enhance cellulose recovery, this study explored alkali/oxidant pretreatment combined with microwave-assisted extraction. A Box-Behnken Design under Response Surface Methodology assessed the effects of sodium hydroxide concentration (1-4% w/v), hydrogen peroxide concentration (20-30% w/v), and microwave power (90-600 W). Optimal conditions (4% NaOH, 25% H2O2, 600 W) yielded 66.6% cellulose. Comparable yields (63-65.5%) were achieved under similar conditions, highlighting the significance of alkali strength and microwave energy, while moderate oxidant levels sufficed for effective delignification and hemicellulose removal. Fourier Transform Infrared (FTIR) Spectroscopy confirmed the removal of non-cellulosic components through diminished lignin and hemicellulose bands, and Thermogravimetric Analysis (TGA) demonstrated improved thermal stability of the treated samples, suggesting higher cellulose purity. 3D Computed Tomography imaging showed enhanced morphology, with reduced porosity and improved particle integrity in the optimized cellulose. These findings establish an efficient and scalable method for cellulose recovery from agricultural residues, offering potential for sustainable bio-based materials and integrated biorefinery systems.

Keywords: *Corn stover; Cellulose fiber; Alkali/acid treatment; Microwave-assisted extraction.*

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Paper No.: IAEC 2025- EE-04

Efficient Removal of Malachite Green Dye from Water Using Anchote Peel-Based Adsorbent

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Abstract

Industrial wastewater, often saturated with various dyes such as malachite green, poses significant concerns for human health and environmental ecology. This study aimed to address this issue by utilizing Anchote peel waste (Coccinia abyssinica) as an effective powdered biosorbent for removing malachite green from aqueous solutions. The biosorbent powder was characterized using techniques including Fourier Transform Infrared Spectroscopy (FTIR), X-ray Diffraction (XRD), and proximate analysis. Batch adsorption experiments were conducted by adding a measured amount of the powdered biosorbent directly to malachite green solutions under controlled conditions. Optimization of the adsorption process was performed using the Box-Behnken design of Response Surface Methodology. The optimization considered four factors: pH (3, 6, and 9), adsorbent dosage (0.5, 1, and 1.5 g/100 mL), initial malachite green concentration (50, 100, and 150 mg/L), and contact time (30, 60, and 90 minutes). The prepared biosorbent exhibited a moisture content of 3.2%, ash content of 5.2%, volatile matter of 54.6%, and fixed carbon of 37%. FTIR and XRD analyses revealed that the biosorbent surface contains a variety of functional groups and an amorphous structure. The maximum malachite green removal efficiency of 99.07% was achieved under optimal conditions of pH 9, contact time of 90 minutes, adsorbent dosage of 1.5 g/100 mL, and initial dye concentration of 50 mg/L. Isotherm studies revealed that the adsorption data aligned with the Langmuir isotherm model, while kinetic studies showed that the pseudo-second-order model best described the adsorption of malachite green onto the Anchote peel-based biosorbent. Overall, the Anchote peel powder demonstrated excellent adsorption performance, suggesting its potential for scale-up in industrial wastewater treatment applications.

Keywords: *Wastewater; Malachite green dye; Adsorption; Anchote peel; Characterization.*

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A Regression Analysis for Sustainable Waste Management in Uzbekistan

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Abstract

Effective waste management is crucial for Uzbekistan's transition towards a green economy. This study employs multiple linear regression and polynomial regression models to forecast municipal solid waste generation in Uzbekistan. Utilizing data from 2014 to 2024, the analysis incorporates key socio-economic and industrial predictors, including population growth, tourism, GDP per capita, and sector-specific investments. The findings provide valuable insights into the primary drivers of municipal solid waste generation and support informed policymaking aimed at enhancing recycling practices and infrastructure. The predictive models developed herein serve as essential tools for strategic waste management planning, contributing significantly to Uzbekistan's sustainability objectives and its broader green economic trans-formation.

Keywords: *Municipal Solid Waste; Green Economy; Regression Analysis; Waste Management.*

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Paper No.: IAEC 2025- EE-06

Renewable Energy Sources in Heating Systems: Practical Applications and Analysis of Scientific Research.

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Abstract

The article analyses the use of solar energy in heating systems of residential buildings and various sectors of the economy, based on scientific research conducted both in foreign countries and in Uzbekistan. The data show that there is significant potential for the efficient utilization of solar energy in the southern regions of the country, considering the available solar resources and climatic conditions. However, there are challenges related to the integration of solar-based heating systems in combined configurations. The studies focus on the effectiveness of using solar energy through the integration of solar collectors, photovoltaic panels, and heat pumps, as well as on reducing energy consumption and optimizing production processes. Special attention is given to methods and directions for the efficient use of solar energy that are suitable for Uzbekistan's specific climatic conditions.

Keywords: *Renewable energy sources; Heating systems; Solar thermal energy.*

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Paper No.: IAEC 2025- EE-07

Numerical Investigation and Thermal Performance Analysis of Smooth Absorber Tube in a Parabolic Trough Solar Collector

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Abstract

The performance of the parabolic trough solar collectors (PTSCs) in terms of thermal efficiency is highly dependent on the design and material characteristics of absorber tubes which control the performance of heat transfer and fluid flow. This paper has conducted a three dimensional computational fluid dynamics (CFD) model in order to examine the thermal and hydrodynamic process of a smooth circular absorber tube at various inlet velocities between 0.20 and 0.32 m/s. Four candidate materials stainless steel, iron, copper and aluminum were compared using the surface temperature distribution, outlet fluid temperature and velocity profiles. Water was used as a heat transfer fluid (HTF) and a constant 1000 W/m 2 of solar flux was directed upon the tube wall. The findings reveal that the increase in mass flow rate lowers surface and outlet temperatures because of the increase in the convectional heat transfer and copper and aluminum always exhibited better thermal performance because of high thermal conductivity. However, stainless steel and iron had higher surface temperature and greater thermal gradients, meaning that they had poorer heat dispersion. These results demonstrate that optimization of materials and flow rate can contribute to maximizing the efficiency and operational stability of PTSC systems and can be used as a reference point in the future to develop new design approaches.

Keywords: *Parabolic trough solar collector (PTSC); Absorber tube; Simulation.*

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Paper No.: IAEC 2025- EE- 08

Thermal Performance Analysis of a Twisted-Tube Absorber in a Parabolic Trough Solar Collector under Variable Flow Conditions

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Abstract

The performance of the parabolic trough solar collectors (PTSCs) in terms of thermal efficiency is highly dependent on the design and material characteristics of absorber tubes which control the performance of heat transfer and fluid flow. This paper has conducted a three-dimensional computational fluid dynamics (CFD) model in order to examine the thermal and hydrodynamic process of a smooth circular absorber tube at various inlet velocities between 0.20 and 0.32 m/s. Four candidate materials stainless steel, iron, copper and aluminum were compared using the surface temperature distribution, outlet fluid temperature and velocity profiles. Water was used as a heat transfer fluid (HTF) and a constant 1000 W/m 2 of solar flux was directed upon the tube wall. The findings reveal that the increase in mass flow rate lowers surface and outlet temperatures because of the increase in the convectional heat transfer and copper and aluminum always exhibited better thermal performance because of high thermal conductivity. However, stainless steel and iron had higher surface temperature and greater thermal gradients, meaning that they had poorer heat dispersion. These results demonstrate that optimization of materials and flow rate can contribute to maximizing the efficiency and operational stability of PTSC systems and can be used as a reference point in the future to develop new design approaches.

Keywords: *Parabolic trough solar collector (PTSC); Absorber tube; Simulation.*

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Paper No.: IAEC 2025- EE- 09

Numerical Study of Thermal Behavior in Flat Plate Solar Collector System

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Abstract

Flat plate solar collectors are widely used in solar thermal applications due to their simplicity, cost-effectiveness, and efficiency in harnessing solar energy. This study presents a comprehensive numerical investigation of heat transfer in flat plate solar collectors using COMSOL Multiphysics. The primary objective is to analyze the thermal performance and efficiency of flat plate solar collectors under various operational and environmental conditions. The simulation model incorporates detailed geometry, material properties, and boundary conditions to accurately represent real-world scenarios. Key parameters such as fluid flow, temperature distribution, convective heat transfer and useful energy gain are examined to understand the underlying heat transfer mechanisms. The simulations showed that the temperature distributions across the absorber plate varied spatially at inlet velocities of 0.3 m/s, 0.35 m/s, 0.4 m/s, and 0.45 m/s. It was observed that lower flow rates improved the efficiency of heat exchange between the absorber plate and the circulating fluid, resulting in higher temperature at the outlet of FPC. This study demonstrates the effectiveness of using computational fluid dynamics (CFD) techniques in enhancing the design and functionality of solar thermal systems.

Keywords: *Numerical modeling; Heat transfer; Flat plate solar collector; Temperature distribution; COMSOL Multiphysics.*

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Paper No.: IAEC 2025- EE- 10

Modelling and Evaluation of Heat Transfer Enhancement in PCM-Based Energy Storage

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Abstract

Phase Change Materials (PCMs) are widely used in thermal energy storage systems due to their high latent heat capacity. However, their inherently low thermal conductivity limits the rate of heat transfer during charging and discharging cycles. This study investigates the enhancement of heat transfer in latent heat storage (LHS) units through the integration of internal fins. Two distinct LHS configurations with embedded U-tube heat exchangers and internal fins were modelled using COMSOL Multiphysics. A transient thermal analysis was conducted over a 12-hour period, focusing on temperature distribution, phase transition dynamics, melting fractions, and total stored thermal energy. Results show that the addition and configuration of internal fins significantly affect the thermal performance of the system. Comparative analysis between the models demonstrates improved melting rates and energy storage in the optimized design. This work contributes valuable insights into the design of efficient PCM-based thermal storage systems for renewable energy applications.

Keywords: *Phase Change Material (PCM); Latent Heat Storage (LHS); Heat Transfer Enhancement; Internal Fins; COMSOL Multiphysics.*

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Paper No.: IAEC 2025- EE- 11

CFD modelling of latent heat storage with cylindrical PCM capsules

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Abstract

The efficient storage and utilization of thermal energy are crucial for advancing sustainable energy systems. Latent Heat Energy Storage Systems (LHESS) leverage the high energy density associated with phase transitions of Phase Change Materials (PCMs), providing an effective solution for thermal energy management. In this study, latent heat storage with cylindrical PCM capsules is analyzed numerically. Detailed charging and discharging simulations during 5 hours are conducted to investigated temperature distribution, phase transition and stored thermal energy. Paraffin waxes were selected as a PCM due to their advantageous thermal characteristics, such as high latent heat of fusion, chemical stability, and non-corrosive nature. Results indicate that at the 5-hour mark, nearly all of the Phase Change Material (PCM) in LHESS has transitioned to the liquid phase when the charging simulation is conducted. Total accumulated energy was about 90000 [kJ] at defined points of LHESS. During discharging period, outlet temperature of LHESS is decreased to 315 [K] which makes it suitable for domestic application.

Keywords: *Latent heat storage; Phase change material; Cylindrical capsules; CFD model.*

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Paper No.: IAEC 2025- EE- 12

Effect of Internal Fins on the Melting Behavior and Energy Storage in Latent Heat Systems

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Abstract

This study presents a comparative numerical analysis of two latent heat thermal energy storage (LHTES) systems: a basic cylindrical configuration and an enhanced model incorporating internal fins. Both systems utilize phase change materials (PCM) as the storage medium and are equipped with U-shaped internal heat transfer tubes for the circulation of heat transfer fluid (HTF). The thermal charging process was simulated using COMSOL Multiphysics by solving the coupled Navier–Stokes and heat transfer equations under transient conditions. Natural convection at the outer surface was also considered to account for ambient heat exchange. The simulations investigated the temperature evolution, fluid flow dynamics, melting behavior, phase transition characteristics, and thermal energy storage capacity of both configurations. Results indicate that the presence of internal fins significantly improves heat transfer within the PCM domain, leading to faster melting rates and enhanced thermal storage performance. The finned LHTES demonstrated a more uniform temperature distribution and higher melting fraction over time, confirming the effectiveness of conductive enhancement structures. These findings provide valuable insights for the optimization of PCM-based thermal storage systems, particularly for applications requiring rapid energy charging and efficient heat management.

Keywords: *Latent heat storage; Numerical approach; Finned configuration; Finite element method (FEM).*

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Bibliometric and Content Analysis of Artificial Intelligence Applications in Thermal Energy Systems: A Review of Scopus-Indexed Publications (2020–2025)

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Abstract

This study presents a bibliometric and content analysis of research publications indexed in Scopus between 2020 and 2025, focusing on the application of artificial intelligence (AI) in thermal energy systems (TES). Using the search string TITLE-ABS-KEY (“artificial” AND “intelligence” AND “applications” AND “thermal” AND “energy” AND “systems”), a comprehensive dataset was collected and analysed. The results reveal a rapidly growing research trend, with annual publications increasing from 20 in 2020 to a peak of 121 in 2024. Engineering, energy, and computer science emerged as the dominant subject areas, while China, India, and the USA led global contributions. Most documents were original research articles (44.8%), followed by review papers (24.8%) and conference papers (17.6%). Author productivity and institutional analysis identified the Chinese Academy of Sciences, King Khalid University, and Intel Corporation among the leading contributors. The findings demonstrate an expanding interdisciplinary research landscape and highlight AI's vital role in optimizing thermal energy system performance and advancing sustainable energy solutions.

Keywords: *Artificial intelligence; Thermal energy systems; Bibliometric analysis; Applications.*

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Paper No.: IAEC 2025- EE- 14

Modelling and Analysis of Flow Behavior in Micro-Scale Hydroelectric Turbine

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Abstract

This study presents a numerical investigation of flow behavior within a micro hydroelectric turbine using Computational Fluid Dynamics (CFD). A three-dimensional model of the turbine was developed and simulated in COMSOL Multiphysics, employing the Turbulent Flow, k-ε physics interface to capture complex flow characteristics. The simulations were conducted under three different inlet flow rates: 1 m^3/s, 2 m^3/s, 3 m^3/s and 4 m^3/s, to assess the influence of discharge variations on turbine performance. The analysis focused on velocity fields, pressure distribution, turbulence intensity, and potential flow separation zones within the turbine housing. Results indicated significant changes in the internal flow structure as the inlet discharge increased, including enhanced turbulence, pressure gradients, and recirculation effects near critical regions of the turbine. The findings provide important insights for the design optimization of micro hydro turbines, particularly in improving flow uniformity and minimizing hydraulic losses.

Keywords: *Micro-hydroelectric turbine; Flow behavior modeling; Computational fluid dynamics (CFD); Renewable energy systems.*

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Paper No.: IAEC 2025- EE- 15

Study of the Influence of Flocculant Dose in Wastewater Treatment

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Abstract

Flocculation is widely used in wastewater treatment processes. The purpose of flocculation is to form aggregates or flakes of finely dispersed and colloidally stable particles. Flocculation is a transport step that results in the collision of persistent particles tending to form large particles (aggregates) that can be easily removed from the treated wastewater by sedimentation, filtration or flotation. Currently, flocculation is widely used in the technology of wastewater treatment of industrial and domestic origin. The mechanism of action of flocculants is based on the phenomenon of adsorption of flocculant molecules on the surface of colloidal particles, the formation of a network structure of flocculant molecules, and the adhesion of colloidal particles due to van der Waals forces. Under the action of flocculants, three-dimensional structures are formed between colloidal particles, capable of faster and more complete separation of the liquid phase. The reason for the appearance of such structures is the adsorption of flocculant macromolecules on several particles with the formation of polymer bridges between them.

Keywords: *Adsorbent; Flocculant; Composition; Coagulation; Efficiency; Impurities.*

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Paper No.: IAEC 2025- EE- 16

Study of the sorption processes of petroleum products in wastewater using natural and modified

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Abstract

This study investigates the sorption behaviour of petroleum products from wastewater using natural and modified bentonites, with comparative analysis against activated carbon. Sorption experiments were conducted under static and dynamic conditions using model and real wastewater samples with varying concentrations of petroleum contaminants. The kinetics of sorption revealed that the process reached equilibrium within 2.5–3 hours, and the maximum sorption capacity was directly proportional to pollutant concentration. Thermally, chemically, and thermochemically modified bentonites exhibited 1.5–3 times higher sorption efficiency compared to natural bentonite. Thermochemically modified bentonite demonstrated the highest sorption capacity (up to 5.67 mg/g). Thermal analysis confirmed structural stability up to 400°C, while IR spectroscopy indicated preservation of the mineral framework after modification. Additionally, the study evaluated the synergistic use of bentonite, kaolin, coagulants, and flocculants to improve wastewater treatment efficiency. Regression models describing the sorption dynamics were developed with high predictive accuracy (R2 > 90%). The results validate the suitability of Navbahor bentonite, particularly in modified forms, as a cost-effective and efficient sorbent for oil-contaminated wastewater treatment.

Keywords: *Sorbent; Technology; Process; Acid; Concentration; Thermal analysis.*

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Paper No.: IAEC 2025- EE-17

Synthesis, Spectroscopic Characterization, and DFT Analysis of Schiff Bases Derived from Benzalacetone and Benzalacetophenone with Alanine

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Abstract

This study investigates the thermal performance and economic feasibility of a solar desalination system with separate evaporation and condensation chambers. Experimental trials were conducted in both laboratory and field conditions, revealing a thermal efficiency of 0.49%. The system produces an average of 5 liters of freshwater daily. The payback period of the device ranges from 6.5 months to 2 years, depending on the price fluctuations of desalinated water. The system consumes 180 MJ of energy per desalination cycle, utilizes 45 m³ of gas, and results in 700 kg of CO_2 emissions. The cost of desalinated water varies between 39.0 USD and 117.0 USD. These findings highlight the device's potential for sustainable and efficient water purification, using solar energy, making it suitable for decentralized applications in regions with limited access to freshwater.

Keywords: *Solar desalination; Techno economic; Analysis.*

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Paper No.: IAEC 2025- EE- 18

Design and Development of Mechanized Vertical Farming System

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Abstract

This study presents the design, fabrication, and evaluation of a low-cost automated biomass pellet cooking stove tailored for roadside eateries in Nepal. With the growing expense and scarcity of renewable fuel sources, and the health and environmental concerns associated with traditional cooking methods, the project aims to offer an alternative cooking solution that is sustainable, affordable, and efficient. Nepal, being an agricultural country where over 62% of the population depends on agriculture, produces significant amounts of agricultural waste each year. While this waste can be converted into biomass pellets—a clean and renewable biofuel— there is limited adoption of technologies that utilize such fuels effectively. This project introduces a cooking stove that addresses this gap by using biomass pellets as fuel. The stove features an automated screw-feed system for pellet supply, controlled air intake for optimized combustion, and built-in safety mechanisms to enhance user convenience and performance. Experimental evaluation through standardized tests, including the Water Boiling Test (WBT), demonstrates that the developed stove achieves an average thermal efficiency of 36% during hot start and 30% during cold start, significantly reducing fuel consumption and pollutant emissions compared to conventional stoves. The results highlight the potential of automated biomass pellet stoves to address energy access, environmental sustainability, and public health challenges in resource-constrained settings.

Keywords: *Biomass Cooking Stove; Pellet Cooking Stove; Automated biomass pellet cooking stove.*

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Health Risks Associated with Traditional Biomass Cookstoves: An Evaluation of Indoor Air Pollution in Rural Kitchens of Nepal

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Abstract

Several billion people, mainly women and children, face long hours of exposure to biomass wood burned inefficiently in traditional cooking stoves. In rural Nepal, cooking is often done using wood-burning stoves within enclosed indoor kitchens, resulting in a high concentration of indoor air pollutants, including PM2.5 and CO. The smoke emitted into their homes exposes them to pollution levels 10-20 times higher than the maximum standards considered safe in developed countries. This study measured concentrations of carbon monoxide (CO) and fine particulate matter (PM2.5) during two-hour cooking sessions conducted over ten consecutive days in a typical Nepali kitchen with one open door and one window. The wood moisture content was maintained under 10%. Real-time pollutant levels of PM2.5 and CO were recorded every minute using Aeroqual and Aerocet 831 monitors, respectively placed one meter above and one meter away from the stove. The average concentrations observed were 26.08 ppm for CO and 269.70 µg/m³ for $PM_{2.5}$—both significantly higher than the World Health Organization's (WHO) 24-hour guideline limits of 4 ppm for CO and 15 µg/m³ for PM2.5. These findings showed that people using biomass fuel on traditional cookstoves are exposed to high concentrations of indoor pollutants, which have long-term, significant effects on their respiratory and cardiovascular health. The finding of this study suggests on adoption of improved cooking solutions in those communities still utilizing biomass fuel for cooking and recommend further research to evaluate their effectiveness in reducing pollutant levels.

Keywords: *Indoor air pollution; Traditional cooking; Biomass stove; PM2.5; Carbon Monoxide;Health risk.*

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Research Methods for Solar Thermal Systems: Efficiency Analysis and Optimization Techniques

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Abstract

Solar thermal systems play a crucial role in renewable energy by converting solar radiation into thermal energy for residential, industrial, and power generation applications. Their efficiency is influenced by absorber material properties, heat transfer processes, and system design. This study explores analytical and computational methods for assessing and optimizing solar thermal system performance. Energy and exergy analyses identify inefficiencies, while Computational Fluid Dynamics (CFD) simulations enhance heat transfer modelling. Optimization techniques, including material selection, machine learning-based predictive models, and exergoeconomic analysis, contribute to improved efficiency and cost-effectiveness. By integrating experimental validation with numerical modelling, this research highlights advancements in absorber coatings, nanofluids, and thermodynamic assessment. The findings provide insights into enhancing the sustainability and efficiency of solar thermal systems, supporting their broader implementation in renewable energy applications.

Keywords: *Efficiency analysis; Optimization techniques; Research methods.*

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Improving Thermal Performance of Solar PTC Using Internal Finned Structure

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Abstract

In the present work, simple and finned absorber tubes of a parabolic trough solar collector (PTC) are considered and analyzed numerically. The three-dimensional numerical simulations have been done by using a COMSOL Multiphysics 6.1 software. This work has also been carried out to investigate temperature distribution, useful energy gains and thermal efficiency of absorber tubes. The variable input data of a solar heat flux condition is applied to receiver tubes for time dependent solver configuration. It can be seen from the analysis that finned receiver tube showed better performance comparing to common one. In the discussion section of this article, temperature variations, useful energy gain, thermal efficiency of the receiver of Solar PTC are provided.

Keywords: *Solar PTC; Absorber tube; Finned structure; Thermal performance.*

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Paper No.: IAEC 2025- EE-22

Charcoal Production from Macadamia Shells Using Super Sun Retort and Kon-Tiki Kiln

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Abstract

Crop residues in Thailand are abundant but underutilized, creating a need for better valorization methods, such as charcoal production. This research aims to utilize agricultural waste by studying the production of high-quality charcoal briquettes from macadamia shells using a Super Sun retort, utilizing heat generated from the Kon-Tiki kiln. This method adds value to surplus agricultural residues and can help reduce air pollution caused by the open-field burning of biomass. In each experimental run, 53-79 kg of firewood and 25 kg of macadamia shells were used. Data on pyrolysis temperature and charcoal yield were collected over a carbonization period of approximately 7 - 8.5 h. The resulting charcoal was then processed into charcoal briquettes. The quality of the charcoal briquettes was tested according to the Thai community production standard (TCPS 238/2004). The results showed that the Super Sun retort produced charcoal at high temperatures (>600 °C), while the temperature above the Kon-Tiki kiln reached 745 °C. The macadamia shells were completely converted into charcoal, with the highest charcoal yield reaching 32%. The charcoal briquettes from macadamia shells had a high calorific value of 7,257 cal/g and a low moisture content of 2.62%, both of which were better than the requirements of the standard. These findings indicate that the macadamia shell charcoal produced in this study has strong potential for use in high-quality charcoal briquette production. The results also suggest that the combination of the Super Sun retort and Kon-Tiki kiln could offer a sustainable and cost-effective solution for charcoal production in developing countries.

Keywords: *Charcoal briquettes; Crop residues; Kon-Tiki kiln; Macadamia shells; Super Sun retort.*

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Paper No.: IAEC 2025- EE-23

Revitalizing the Agricultural Sector in the Midst of Aggressive Tin Mining: Half-hearted Agricultural Politics in Bangka Belitung

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Abstract

The idea of returning to agriculture is an initiative aimed at revitalizing the agricultural sector in the Bangka Belitung Islands province. Located in eastern Sumatra, this province is one of the few island provinces in Indonesia with abundant tin resources. However, long before tin became an openly managed commodity, agriculture—particularly pepper and rubber production of small scale farmers—was the mainstay of the local economy. Since tin mining became widespread, the plantation sector has largely been neglected. Efforts to revitalize the agricultural sector have not been accompanied by a strong commitment from local governments. Budget allocations for the agricultural sector tend to be limited in planning documents. At the same time, land degradation caused by mining, changes in community culture, and variations in plant diseases have further exacerbated the agricultural sector's critical state. Through an analysis of regional development planning documents, interviews with government, farmer, and local association, also observations, this study found that policies intended to strengthen the agricultural sector, such as regulatory support, financial assistance, agrarian governance, and research support, have not been seriously implemented. Agricultural politics remains half-hearted, indicating that extracting natural resources remains the primary choice, despite the environmental damage it causes. In this context, the approach of agricultural politics showed how the decision-making process is inconsistent between the problem and policy planning.

Keywords: *Agricultural politics; Mining Aggression; Tin; Bangka Belitung.*

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Paper No.: IAEC 2025- EE- 24

Identification and Removal of Negative Biomass Samples via Scatter Plot Analysis to Improve GWP Predictive Modeling

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Abstract

Accurate prediction of Global Warming Potential (GWP) from biomass constituents is essential for evaluating the sustainability of bioenergy sources. This study applies scatter plot regression analysis as a diagnostic tool to identify and remove biomass samples with weak or inconsistent correlations to elemental composition. The results show that wood-based species, such as Alnus, demonstrated strong linear relationships with GWP (R^2 values up to 0.69 for carbon and 0.68 for oxygen), while several non-wood species (bagasse, bamboo, maize residues) showed very low correlations (R^2 often <0.05), obscuring predictive accuracy. Removing these low-contributing samples led to steeper regression slopes, higher overall R^2 values, and improved model interpretability. This demonstrates that targeted data filtering significantly enhances the robustness of GWP prediction. Beyond technical performance, the approach offers a transparent and practical method for improving biomass datasets, supporting more reliable bioenergy assessments, climate policy decisions, and sustainability planning.

Keywords: *Biomass, GWP; Scatter Plot; Regression; Ultimate Analysis; Model Optimization.*

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Paper No.: IAEC 2025- EE- 25

Optimization of Microwave Pyrolysis for Biochar Production from Agroforestry Byproducts: Exploring Parameters and Operational Modes

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Abstract

Microwave assisted pyrolysis offers a rapid, energy efficient route to convert agroforestry residues into high value biochar but is hindered by hotspots, temperature non-uniformity, imprecise measurements, partial carbonization, and poor replicability. This study comprehensively investigates process variables, operating modes, and quantification techniques to address key challenges and to optimize biochar production. Hundreds of systematic experiments were conducted on various agroforestry residues, examining more than ten control parameters and classifying them by their impact on yield and quality. Four operating modes were investigated: constant power with/without high - temperature alarm, fixed temperature, and controlled heating - rate; and two novel metrics (carbonized amount and absolute yield) were introduced alongside traditional metrics to more accurately quantify biochar production and quality. Additionally, a central-composite response-surface design (30 runs at 300–700 W and 20–60 min) applied to oak sawdust, perilla stem and rice straw to model seven responses for optimization. Power and process time emerged as the primary drivers of yield and carbonization; heating rate and target temperature acted as fundamental dependent factors. Constant - power operation without alarm achieved the highest reproducibility and absolute yield (up to 33.85%), whereas controlled ramping produced biochars with HHV >30 MJ/kg and fixed carbon >70%. Response surface model demonstrated excellent fits (R^2 up to 0.96) and confirmed that power and time significantly influenced all responses. Carbonization and HHV stabilized from optimal thresholds, while absolute yield peaked at 500 W/40 min. Energy efficiency was maximized at 500 W/20 min (70.8 % for oak, 54.1 % for perilla, 58.4 % for rice straw). Multi-response optimization identified a global optimum at 616 W/26 min for oak and optima of 590 W/20 min (rice straw) and 594 W/29 min (perilla). Oak sawdust offered the widest operational window and highest energy metrics; rice straw achieved near-complete carbonization at minimal energy; perilla delivered intermediate performance with rapid carbonization. This tunable framework supports tailored biochar production for fuel, soil amendment, adsorption or carbon sequestration.

Keywords: *Agricultural and forestry biomass; Thermochemical Conversion; Microwave pyrolysis; Energy efficiency; Response Surface Methodology; Absolute yield, Biochar production.*

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Indoor Air-Pollution in Agricultural Countries and its Effects on Brain Development in Early Childhood

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Abstract

Indoor air pollution has a big impact on how children grow and develop, especially in countries with lower incomes where people often use biomass fuels and don't have good ventilation. Kids are more vulnerable to harmful toxins in the air because their immune and respiratory systems are still developing. They can be affected by these toxins mainly through breathing, but also through skin contact and what they eat. There's growing evidence connecting indoor air pollution to serious problems like stunted growth, difficulties in thinking and moving, and a higher chance of getting respiratory infections. Research shows that pollutants like fine particles, carbon monoxide, and pesticides can harm brain development. Kids who are exposed to these pollutants before birth and in their early years may end up with lower scores in thinking tests, behavioral issues, and inflammation in the brain. The situation is particularly bad in countries like India, where traditional cooking methods lead to high levels of indoor air pollutants, hitting women and young children the hardest. To help protect child health and development, it's important to tackle indoor air pollution by using cleaner fuels, improving ventilation, and creating better public health policies. This article tries to reflect on effects of air-pollution on growth and development of children in agricultural countries.

Keywords: *Agriculture; Solid Fuel Burning; Smoke; Indoor Air; Growth; Cognitive Development.*

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Paper No.: IAEC 2025- EE- 27

Fusion of Geospatial and Field Data for Predicting Sugarcane Harvest Capacity using Machine Learning

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Abstract

The shortage of agricultural labor in Thailand, particularly during harvest season, has made relying on sugarcane harvesters a crucial alternative. However, the efficiency of these harvesters often falls short of expectations due to the diverse conditions of sugarcane fields across different areas. To address this, this research focuses on developing a Machine Learning model to predict sugarcane harvesting capacity by integrating field data with imagery data. The study was conducted on 105 sugarcane plots in Sa Kaeo Province, Eastern Thailand. We collected plot shape data from the JD Link system installed on sugarcane harvesters, along with crucial field data such as pre-harvest yield volume and row width. These data were then used to build three types of machine learning models: Regression, Random Forest, and Neural Network. The results showed that the Random Forest model performed best, yielding a coefficient of determination (R2) of 0.625. This indicates its reliable ability to predict harvesting operational efficiency.

Keywords: *Sugarcane harvesting; Field capacity; Machine learning; Precision agriculture.*

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Paper No.: IAEC 2025- PFE-01

Rapid Evaluation of Succinic Acid in Sake Using Excitation-Emission Matrix and Chemometrics

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Abstract

Succinic acid, a major contributor to sake acidity, plays a key role in shaping its taste, mouthfeel, and aroma. Accurate acidity control is essential for ensuring consistent product quality and meeting consumer expectations. However, traditional titration-based methods are destructive, time-consuming, and require complex sample preparation. This study explores the use of excitation-emission matrix (EEM) fluorescence spectroscopy as a rapid, non-destructive alternative for predicting titratable acidity in sake. EEM spectra were collected from 100 sake samples, and acidity values expressed as succinic acid equivalents were determined via titration. Partial least squares regression (PLSR) models were developed using pre-processed spectral data, including Rayleigh scattering removal and logarithmic transformation to enhance model performance. Among the evaluated spectral subregions, Region 1 (Ex: 270–310 nm / Em: 285–440 nm) yielded the best cross-validation results (R^2CV = 0.5763, RMSECV = 0.0133 g/100 mL, RPDCV = 1.5994), suggesting a strong link between acidity and fluorescence signals from phenolic compounds. In contrast, Region 3, dominated by riboflavin fluorescence, exhibited overfitting and instability. These results support the potential of EEM fluorescence combined with chemometrics as a semi-quantitative tool for acidity prediction in sake, though further refinement is needed for precise quantification.

Keywords: *Excitation-Emission Matrix fluorescence spectroscopy; Sake acidity; Chemometrics; Partial least squares regression; Non-destructive analysis.*

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Paper No.: IAEC 2025- PFE-02

Improving Pellet Quality and Throughput via Die Type and Steam Conditioning Temperature Optimization in Cattle Feed Production

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Abstract

This study addressed production challenges in high-fiber cattle feed pelleting, where conventional die design and low steam temperature led to die wear, excessive fines, and low throughput. The effects of pellet die type and steam conditioning temperature on pellet quality, energy consumption, and throughput were evaluated using a full factorial experiment at a commercial feed mill. Two die types (standard and counter drilled) and five steam temperatures (65–85 °C) were tested. Key parameters included pellet durability index (PDI), dust content, motor current, production rate, and nutritional composition. Results showed that steam temperature significantly influenced pellet quality ($p < 0.05$), with optimal PDI (~97%) and minimal dust (~1.5%) achieved at 80–85 °C. Die type significantly affected energy efficiency and output ($p < 0.001$); the counter drilled die reduced motor current by up to 18% and increased throughput by ~20%. No significant differences were found in protein, fiber, or fat content ($p > 0.05$), indicating nutritional stability. The combination of high-temperature steam conditioning and counter drilled die offers an effective strategy to enhance pellet quality and reduce energy load. This approach is suitable for high-capacity cattle feed mills aiming for consistent performance and improved operational efficiency.

Keywords: *Pellet durability index (PDI); Steam conditioning temperature; Counterdrilled die; High-fiber cattle feed; Energy efficiency.*

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Paper No.: IAEC 2025- PFE- 03

Chemical Composition and In Silico Study of the Biological Activities of Alkaloids from Peganum harmala

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Abstract

Despite the broad ethnopharmacological use of Peganum harmala, comprehensive studies on the chemical composition of its bioactive alkaloids and their biological properties remain limited. In this study, the results of the experimental investigation of the chemical composition of Peganum harmala are presented, along with conclusions regarding the biological activity of peganine and deoxypeganine based on quantum-chemical calculations and in silico approaches. Initially, analyses were performed using the HPLC method at different developmental stages of the plant. The highest concentration of peganine was observed during the branching stage of P. harmala (up to 83% in samples collected on May 14, 2023). Quantum-chemical calculations within the framework of density functional theory (DFT) revealed that both peganine and deoxypeganine possess favorable electronic properties. In particular, peganine exhibited a high electrophilicity index and significant electron affinity. Molecular electrostatic potential (MEP) analysis identified nucleophilic and electrophilic reactive sites, while density of states (DOS) spectra confirmed their system-to-system activity. The biological activities of the main constituents of the plant, namely peganine and deoxypeganine, were further evaluated using in silico methods. According to molecular docking simulations with the human-derived 6s5a protein, peganine demonstrated a binding affinity of –7.59 kcal/mol, while deoxypeganine exhibited a slightly stronger interaction with a binding affinity of –8.13 kcal/mol. These in silico findings suggest that P. harmala alkaloids, particularly peganine, hold promising potential for therapeutic development. Future research should involve in vitro and in vivo studies to further evaluate the bioactivity of alkaloids isolated from the plant extract.y.

Keywords: *Alkaloids; DFT; Garmalin; Peganum harmala.*

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Synthesis, Spectroscopic Characterization, and DFT Analysis of Schiff Bases Derived from Benzalacetone and Benzalacetophenone with Alanine

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Abstract

This comprehensive study investigates the synthesis, characterization, and potential biological activities of novel Schiff bases derived from the condensation reactions of benzalacetone and benzalacetophenone with alanine. The compounds were synthesized via condensation reactions between the respective carbonyl compounds and alanine, yielding stable imine derivatives. The structures of the synthesized Schiff bases were confirmed using proton nuclear magnetic resonance (1H NMR), carbon-13 nuclear magnetic resonance (13C NMR), and infrared (IR) spectroscopy. The IR spectra revealed characteristic imine (C=N) stretching vibrations, indicating successful Schiff base formation. DFT (Density Functional Theory) calculations were performed at the B3LYP/6-311G(d,p) level to optimize the molecular geometries and to compute vibrational frequencies, which were found to be in good agreement with experimental data. Additionally, frontier molecular orbital (HOMO–LUMO) analysis was carried out to assess the electronic properties and chemical reactivity of the compounds. The results contribute to a deeper understanding of the structural and electronic characteristics of amino acid-derived Schiff bases, highlighting their potential for applications in coordination chemistry and materials science.

Keywords: *Schiff bases; Benzalacetone; Benzalacetophenone; Alanine; IR spectroscopy.*

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Paper No.: IAEC 2025- PFE- 05

Development of a Practical and Sustainable Meat Drying System Using Solar Energy

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Abstract

This research presents the development of a practical and sustainable meat drying system powered by solar energy, aimed at improving the quality and safety of sun-dried meat. The system integrates solar photovoltaic panels with a controlled heating and ventilation unit, enabling consistent drying conditions even in low or no sunlight. The prototype, measuring 90 × 120 × 120 cm3, stores solar energy in batteries to power temperature and airflow regulation, achieving a maximum thermal efficiency of 80%. Comparative evaluations with traditional sun drying methods showed improved product consistency, hygiene, and shelf life. The dried meat from this system exhibited desirable sensory and physical qualities, including reduced moisture content (20%) and a deep red color (L* = 22.70±0.86, a* = 3.68±0.50, b* = 4.47±0.27). Texture analysis revealed firmer products, with compression forces ranging from 10 to 13.5 N depending on drying conditions. Economic analysis indicated a feasible production cost and break-even point. This solar-powered dryer reduces contamination risks and seasonal limitations, offering a scalable, energy-efficient solution for local meat processors and rural communities. The system contributes to sustainable food processing and has strong potential for further innovation and commercialization. Keyword. Solar dryer, Sun-dried beef, Renewable energy, Food processing, Rural technology.

Keywords: *Solar dryer; Sun-dried beef;Rural technology.*

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Influence of using groundwater in preparation of wheat grain for flour milling on yield and technological properties of flour

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Abstract

The article covers the influence of underground and potable water samples used in the preparation of wheat grains for flour milling on the yield of flour and its quality parameters. The purpose of research is experimentally analyzing the effect of using groundwater on the yield and technological properties of wheat grain for flour milling. Underground (artesian) water samples from Chilonzor and Sergeli districts and potable water samples from Yunusabad district of Tashkent city selected for the study were taken according to UzDST 951:2011, and their organoleptic parameters were determined according to GOST 2874-82 by modern chemical and physical-chemical methods. It was established that organoleptic indicators of groundwater samples taken from Chilonzor and Sergeli districts, respectively, were in excess of the standards SanPiN No. 0366-19. T-2019 in total minerals 492÷388 mg/dm^3, total hardness 17÷2.6 mg/dm^3, sulfates 500 mg/dm^3.

Keywords: *Wheat; Grain; Underground water; Potable water; Organoleptic.*

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Assessment of Chemical Element Accumulation and Dispersion in Degraded Soils of the Southern Aral Sea Region for Sustainable Land Use

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Abstract

This article presents the findings of a study on the accumulation and dispersion patterns of chemical elements in the soils of the Southern Aral Sea region. The research focuses on identifying spatial variations in the concentrations of salts, minerals, and heavy metals across selected transects (Muynak–Nukus–Ellikkala) in the Republic of Karakalpakstan. Results indicate generally low concentrations of most elements—except sodium (Na) and potassium (K)—with limited mobility due to alkaline pH and oxidizing soil conditions. The study underscores the environmental implications of soil geochemistry in a region severely affected by ecological degradation. By analyzing geochemical trends, the research contributes to a better understanding of land degradation, soil fertility, and environmental risks, offering recommendations for sustainable land management in arid ecosystems impacted by the desiccation of the Aral Sea.

Keywords: *Karakalpakstan; Aral Sea region; Soil geochemistry; Environmental degradation; Element accumulation; Sustainable land use.*

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Vegetation cover as an indicator of degradation and restoration of ecosystems in the Aral Sea region

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Abstract

The study analyzes changes in the vegetation cover of the Aral Sea region and its role in the processes of ecosystem degradation and restoration. The effectiveness of phytomelioration and the introduction of autochthonous plant species - such as saxaul (Haloxylon persicum), fourwing saltbush (Atriplex canescens), and wormwood (Artemisia) - as well as other restoration methods, is assessed. The research is based on satellite data obtained with Landsat as well as Sentinel missions, as well as field work interpretation conducted in phytomelioration implementation regions. Dynamics of vegetation throughout some decades as well as phytomelioration impacts on ecosystem state have been presented. Based on results, it is concluded with regard to necessity of integrated measures in ecosystem recovery as well as long-term monitoring potential in regions.

Keywords: *Vegetation cover; Degradation; Ecosystem restoration; Aral Sea region; Phytomelioration.*

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