

MINISTRY OF EDUCATION, INNOVATION AND TALENT DEVELOPMENT SARAWAK

Synthesis

S A R A W A K

2025
ISSUE NO.3



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First published in 2024

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Published by
 Ministry of Education, Innovation and Talent Development Sarawak
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Design & Layout by
 Bumi Serasi, Sarawak, Malaysia

ISSN No. : 3036-0293

Printed in Malaysia

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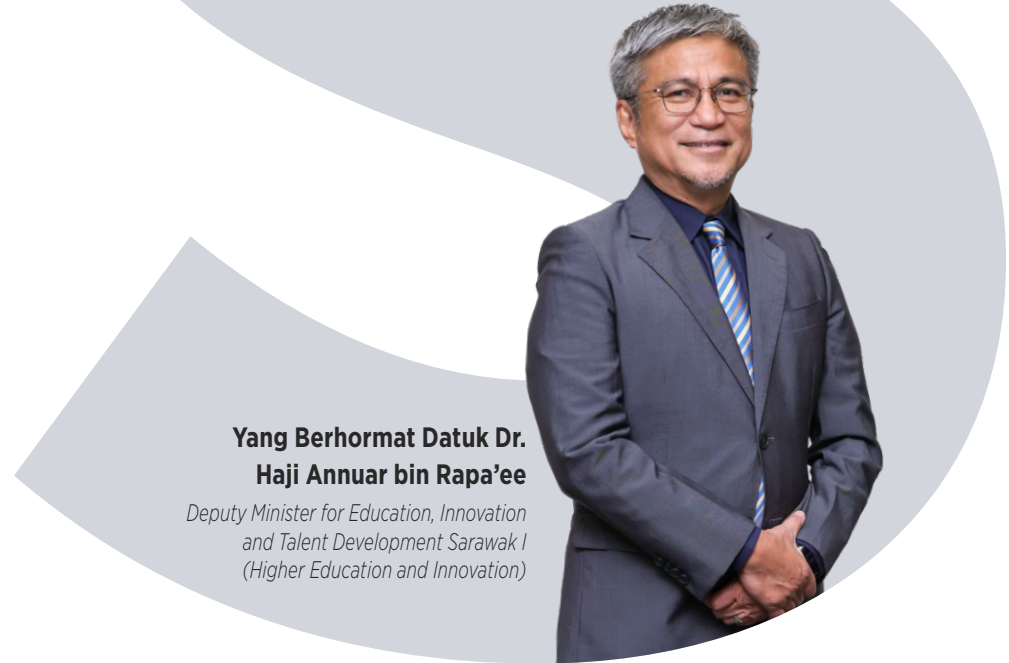
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FOREWORD

from

**Yang Berbahagia Datu
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*Permanent Secretary
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and Talent Development Sarawak*

It is with great pleasure that I present the third issue of Synthesis Sarawak, an edition that brings together diverse and inspiring stories of innovation, research, and collaboration across Sarawak's universities and research institutions. Under the collective theme "The Future of Sarawak," this issue celebrates the remarkable achievements of our academic and research communities as they contribute to shaping a more resilient, sustainable, and knowledge-driven Sarawak.

This edition features contributions from CENTEXS, i-CATS University College, Konsortium Universiti Universitas Borneo (KUUB), Sarawak Biodiversity Centre (SBC), Sarawak Skills, Swinburne University of Technology Sarawak, Curtin University Malaysia, CRAUN Research, Sarawak Tropical Peat Research Institute, Sarawak Research and Development Council (SRDC), and the University of Technology Sarawak (UTS), each offering unique insights into the progress being made across disciplines.

One of the key highlights, "Centexs Aerospace Academy: Powering the Future of Aerospace Innovation in Sarawak," showcases the state's bold vision to establish a

foundation for aerospace excellence. The focus on developing local talent, strengthening infrastructure, and integrating air mobility solutions demonstrates Sarawak's commitment to positioning itself as a regional leader in aviation and aerospace technology. Complementing this, "Aerospace Vehicle Design for Unmanned Aircraft 'Drone'" underscores the growing local capability in designing and developing unmanned aerial systems (UAS). Together, these initiatives signal a confident step towards achieving technological sovereignty and long-term resilience in this high-impact sector.

Equally significant is KUUB's visionary endeavor "Bridging Borders, Building Futures", which exemplifies Borneo's collective drive for unity and progress through education. By connecting universities across East Malaysia, Brunei Darussalam, and Kalimantan, KUUB stands as a beacon of collaboration under the guiding value of Borneo Bermartabat, upholding the region's dignity, heritage, and identity while advancing knowledge, innovation, and inclusivity.

The nurturing of scientific talent also takes centre stage in "Nurturing Scientific Talent for the Future of Sarawak," which highlights SBC's efforts in cultivating the next generation of scientists through training and internship programmes. Such initiatives plant the seeds of curiosity and innovation, ensuring that Sarawak's youth are well-equipped to steward the state's biodiversity, biotechnology, and sustainable development.

Innovation in sustainability is further exemplified in "The Smart Solar House," a collaboration between Sarawak Skills and Neuto Energy Sdn. Bhd., which demonstrates how education and industry can jointly drive green innovation. By integrating solar technology with education, research, and community engagement, the project offers a practical model for addressing environmental challenges while preparing the workforce for a low-carbon future.

Among the many other features that shape this issue, "Submarine Groundwater Discharge (SGD) as an Emerging and Needed Research for Marine Ecosystem Sustainability" draws attention to the unseen yet critical processes affecting our coastal environments. SGD through which nutrients, metals, and pollutants flow from land to sea poses both challenges and research opportunities for Sarawak's marine ecosystems. It highlights a growing frontier of environmental research essential to maintaining the health and sustainability of coastal and marine ecosystems.

The importance of nurturing human capital and innovation also resonates through "Future of Borneo: Nurturing a STEM-Ready Generation," which reminds us that the strength of tomorrow lies in the minds of our youth. Programmes such as the SRDC BrightSparx Grant and the STEM Catalyst Programme are shaping a generation ready to embrace science and innovation for an inclusive, high-tech Sarawak.

Meanwhile, "Shaping the Future of Dialysis Care in Borneo" introduces FistulaFix, a locally developed, award-winning medical innovation revolutionising post-dialysis care, embodying the spirit of empathy and technological excellence born from Sarawak's ingenuity.

Sarawak's growing emphasis on agro-based innovation is captured in "Kenaf Seed Soft Tofu", which spotlights kenaf as the state's "next green gold," and "Sago Reimagined: Youth Powering Borneo's Agro-Food Future," which repositions sago as both a symbol of cultural heritage and a modern, sustainable food source aligned with global goals for health and zero hunger. Likewise, "Borneo's Palm Biomass: Transforming Waste into Black Gold" and "The Renewal of Oil Palm Plantations: Digging Deep into Peat Chemistry" explore how research and technology can unlock value from natural resources, supporting sustainability and resilience in the bioeconomy.

In materials science, "From Pond to Product" explores the potential of water hyacinth as a sustainable composite reinforcer, while "Tiny Bees, Big Clues" bridges traditional ecological knowledge and modern technology to better understand Borneo's stingless bee honey, an evidence to the region's biodiversity and wisdom.

The theme of technological transformation continues with "The Pick-up and Drop-off (PUDO) Index System," which provides data-driven insight for improving last-mile logistics across Sarawak's challenging terrains. Similarly, "Digital Transformation in Borneo's Veterinary Sector" highlights how artificial intelligence and digital monitoring tools are transforming disease surveillance, protecting both animals and communities.

Environmental and educational research are also strongly represented. "The Living Landscape of Sarawak Tropical Peatland" offers an illuminating perspective on the intricate relationships between biodiversity, soil, and atmospheric processes elements vital to global climate balance. In parallel, "Online Learning Satisfaction: A Longitudinal Perspective" reflects on how the pandemic reshaped higher education, reminding us of the adaptability, resilience, and digital readiness required in an evolving academic landscape.

Together, these stories form a mosaic of Sarawak's transformation where science, innovation, and collaboration converge to chart a sustainable and inclusive path forward. They exemplify how our institutions and people are embracing change with creativity, purpose, and unity.

In the spirit of *carpe diem*, let us seize the moment and strive forward with optimism and determination. Congratulations to the editorial team, especially the University of Technology Sarawak, for their diligence, hard work, and commitment in producing this third issue of Synthesis Sarawak. May it continue to inspire progress and pride for the years ahead.

NURTURING SCIENTIFIC TALENT FOR THE FUTURE OF SARAWAK

by Sarawak Biodiversity Centre (SBC)

INTRODUCTION

When envisioning the future of Sarawak, the development of our young talents cannot be ignored. They are the ones who will become future leaders, policymakers, and decision makers, carrying forward the stewardship of the rich biodiversity, cultural wisdom, and sustainable innovation for Sarawak.

As a centre for biodiversity research, bioprospecting, traditional knowledge documentation, and sustainable utilisation of Sarawak's biological resources, Sarawak Biodiversity Centre (SBC) plays an important role in planting the seeds of talents in science and biotechnology through its Industrial Training and Internship Programmes.

This effort aligns with the Sustainable Development Goals (SDGs), particularly Goal 4 (Quality Education), Goal 8 (Decent Work and Economic Growth), and Goal 15 (Life on Land), ensuring that the nurturing of scientific talent contributes towards a resilient and sustainable future. It also supports the Post Covid-19 Development Strategy (PCDS) 2030, which highlights human capital development and innovation as key drivers of Sarawak's long-term progress.

INDUSTRIAL TRAINING AND INTERNSHIP AT SBC

The trainees will be immersed in research, as well as the natural environment of the rainforest to develop future scientific talents that skim through biodiversity for the benefit of Sarawak. They will be exposed to ongoing research in ethnobotany, analytical chemistry, microbiology, molecular biology, and product development. The programme aims to equip students with practical and hands-on experience in research through community engagement, fieldwork, laboratory processes and best practices.

Interns are assigned to various research and operational units where they work alongside experienced scientists and officers. From completing assigned projects, to

collecting plant specimens in remote villages, conducting laboratory-based experiments, and participating in outreach programmes, the experience is holistic and multidisciplinary. This cross-functional experience will strengthen the understanding of the connection between traditional knowledge and science.



Figure 1: Intern Karthiyaini A/P Chandran, a Bachelor of Science in Aquaculture student from Universiti Putra Malaysia, Bintulu Campus, facilitating hands-on activities with primary school students during S-CaT Fair STEM Playground held from 5th to 6th July 2025 at Borneo Convention Centre Kuching.



Figure 2: Interns, Sherrinin Tikong, a Bachelor of Biomolecular Science student from Universiti Teknologi Mara Shah Alam, and Poon Yi Jing, a Bachelor of Science (Applied Plant Sciences) student from Universiti Putra Malaysia, Bintulu Campus, participating in marketing and sales of SBC's nature-based products at the Rainforest World Music Festival 2025 held from 20th to 22nd June 2025 at Sarawak Cultural Village. They also engaged with the public to raise biodiversity awareness and promote SBC's research initiatives.

WHAT THE INTERNS SAY

Since the implementation of the programme, SBC has hosted both local and international interns from universities across Malaysia and abroad. Many of them cite the training as a transformative period in their academic and personal development.



Figure 3: Intern Nasrin bin Adzmuri, a Bachelor of Bioindustry Science with Honours student from Universiti Putra Malaysia, Bintulu Campus, cleaning the photobioreactor (PBR) components as part of algae cultivation maintenance procedures at SBC's Algae Cultivation Facility (ACF).

With a background in Bioindustry Science, Nasrin bin Adzmuri began his professional journey through an internship at SBC's Algae section from October 2022 to February 2023 during his studies at Universiti Putra Malaysia, Bintulu Campus.

"I learned how to cultivate algae, maintain cleanliness in photobioreactor plastics, and ensure their viability," he shared. Nasrin acknowledged that his academic background provided the theoretical foundation, while the internship served as a valuable stepping stone in preparing him for the working world. He is now working as a Production Executive at the Ganoderma Cultivation Facility which is operated under a collaboration between SBC and the private sector.

Rania Migaou, a former international intern from Biotechnology Engineering School SupBiotech Paris, shared that her internship experience from May to August 2023 provided her with an invaluable opportunity to gain hands-on research experience, including the isolation and maintenance of Actinobacteria strains native to Sarawak, protein quantification using the Bradford assay, and cellulase enzymatic activity tests. Beyond

the lab, Rania participated in SBC's outreach and conservation initiatives such as the Sarawak Biodiversity Day Tree Planting and Talang-Satang Conservation Trip.

"These experiences allowed me to discover more about Sarawak's culture, biodiversity, and conservation efforts while meeting inspiring people," she shared. Rania continues to highlight SBC's unique blend of science and traditional knowledge with her peers during discussions and official events. She is currently working as a Serialisation Project Engineer at Cooper Consumer Health in France. Since August 2016, SBC has seen growing interest from students from countries such as France, seeking internship placements to gain cross-cultural scientific exposure, particularly in ethnobotany and natural product research.



Figure 4: Rania Migaou, an international intern from Biotechnology Engineering School SupBiotech Paris, participating in the Sabal Forest Reserve Tree Planting event as part of SBC's outreach and conservation activities.



Figure 5: Intern Geraldine Lee Phey Siing, a Bachelor of Science with Honours (Resource Biotechnology) student from Universiti Malaysia Sarawak (UNIMAS) preparing for Enzyme Linked Immunosorbent Assay (ELISA).

Geraldine Lee Phey Siing, a Resource Biotechnology graduate from Universiti Malaysia Sarawak (UNIMAS), completed her internship with SBC's Molecular Biology section from July 2023 to October 2023.

"My internship attachment allowed me to apply academic knowledge in a real-world setting, gaining hands-on experience in molecular techniques such as Polymerase Chain Reaction (PCR), plant DNA extraction, PCR product purification, agarose gel electrophoresis, and ELISA-based immunoassay antiviral property screening projects," she shared.

Currently employed as a Research Assistant for the Sarawak Infectious Disease Centre (SIDC), Geraldine comments that both the technical and soft skills gained during her internship have proven invaluable in her professional role. She credited the internship experience for strengthening her time management, perseverance, and communication skills, which continue to enhance her performance at work.

IMPACT AND FORWARD OUTLOOK

Beyond technical skills, SBC's Industrial Training Programme cultivates soft skills, ethical awareness, and a deep respect for Sarawak's ecological and cultural landscapes. Interns often go on to pursue careers in research, conservation, education, and public policy, becoming ambassadors of sustainable science in their own right.

The programme also plays a crucial role in promoting ethical bioprospecting and awareness of Access and Benefit Sharing (ABS), contributing to broader goals under the Nagoya Protocol and Sarawak's regulatory framework (Sarawak Online Research Application System). Through this, SBC is not only shaping individuals but influencing the region's scientific culture towards responsibility and inclusivity.

SAGO, YOUTH AND THE NEW AGRO-FOOD WAVE

by CRAUN Editorial Team

Sarawak stands at a crossroads. Blessed with fertile land, lush forests, and abundant waterways, it holds the natural advantage to become one of the region's most secure food producers. Yet in 2024 alone, the state spent over RM6.44 billion on food imports. Local agriculture is now grappling with a generational gap and fading relevance among the youth.

According to the Department of Statistics Malaysia (DOSM), 43% of Sarawak's farmers are aged 60 and above, while only 12% of youth are engaged in agriculture. With many young people chasing urban careers, farming has acquired the reputation of a "sunset industry" - associated with sweat, mud, and meagre pay rather than with innovation and opportunity. However, agro-food is not just about survival - it is about security, resilience, self-sufficiency, and identity. Without a new generation of farmers and agri-entrepreneurs, who will feed Sarawak?

Sago (*Metroxylon sagu*) sits at the intersection of heritage and opportunity. Deeply embedded in Sarawak's food culture, sago is now gaining renewed interest for its health benefits. Amid calls to diversify staples and meet growing interest in gluten-free diets, glycaemic control, and gut health, this indigenous crop is steadily reclaiming the spotlight.

Driving this resurgence two figures stand out: Wedjohn Darimi, a hands-on sago farmer, and Mohd Hafidz Rohani, a modern sago-preneur. One is knee-deep in the field, harvesting sago logs to keep the industry alive. The other is taking sago products across borders, proving that Sarawak's traditional ingredients can thrive on modern, global shelves. Together, they offer a glimpse of what Sarawak's agro-food economy can become.

FROM VILLAGE BOY TO SAGO ICON

At 38, Wedjohn Darimi is considered “young” in a field dominated by elders. Hailing from Mukah, an area where sago palms flourish, he grew up assisting his family in harvesting and processing sago logs. His perseverance and dedication to modernise traditional sago farming earned him second place in the *Pertandingan Kebun Balau 2022*, organised by CRAUN Research Sdn Bhd - an achievement which led to him being coined as *Ikon Belia Sagu*, a title created to inspire youth participation in the sago industry.

When asked what led him into sago farming, he reflected, “I didn’t have the opportunity to pursue higher education, as life was tough since childhood. I grew up in a sago- based community, so getting involved in this field felt like a natural path for me.”

While many peers left for city jobs, Wedjohn stayed - not only out of duty, but also because he saw the potential for a steady income from sago. “Nowadays, I rarely see young people interested in planting sago trees,” he shared. However, Wedjohn also acknowledged that the job is not without its challenges. “There are a lot of challenges, especially with unstable sago log prices, and the difficulty of accessing the areas where the sago palms are to be harvested. Some places are not properly organised,” he said. Even for a young guy like him, the terrain has proven to be a challenge.

Despite the challenges, Wedjohn remained optimistic. “In my opinion, sago farming can still provide a good income because the resource is always available,” he said. “Almost every day, we’re still cutting down sago palms.” Still, he is clear-eyed about what is needed to draw youth into the field - professionalisation through stable salaries, EPF, SOCSO, and village-based processing facilities to ease logistics. Only then, he believed, will young people see it as a viable career.



Figure 1: Wedjohn Darimi (third from left) came in second place in *Pertandingan Kebun Balau* organised by CRAUN Research Sdn Bhd in conjunction with *Seminar Industri Sagu 2022*.

FROM HERITAGE TO GLOBAL SHELVES

If Wedjohn is the muscle, Mohd Hafidz Rohani, 41, is the merchant. An entrepreneur who sharpened his business acumen through global training, including from Oxford and Cranfield University. Today, Hafidz is the Managing Director of IANA Corporation Sdn Bhd, a company based in Miri, known for biscuits, bread, and layered cakes. But it is their gluten-free sago cookies, made in collaboration with CRAUN Research, that are turning heads.

“As the owner of IANA Corporation, I have always believed in exploring local ingredients to create unique products. We saw sago as a local resource with great potential that had not yet been fully explored in the modern food industry,” Hafidz said. “Our inspiration came when we partnered with CRAUN, who shared their knowledge about the nutritional benefits and potential of sago.”

Through this collaboration, IANA gained both formulation and production support. “CRAUN has played an important role in supporting us in developing our gluten-free sago cookies. They provided us with technical guidance, formulation support, and also equipped us with the machine to assist in our production.”

The outcome? A cookie that has charmed taste buds from Qatar to Japan - and soon, the United States. “In terms of taste and texture, sago flour gives our cookies a light, crisp bite that many customers enjoy,” he shared. Naturally gluten-free, sago cookies appeal to health-conscious consumers and those with gluten intolerance alike - offering a treat that is inclusive and enjoyable for all. “One feedback that stood out was when a customer shared that our cookies allowed them to enjoy treats without worrying about gluten, making them feel included during gatherings with family and friends.” For some, the sago cookie is more than just a treat - it is a connection.

But like any business venture, scaling had not been easy. Hafidz had to fine-tune recipes to maintain consistent quality at larger volumes. Rebranding sago as a modern, premium ingredient also demanded persistent customer engagement and education - but the effort is paying off. From humble beginnings, income has been steadily growing, boosted by IANA’s participation in international expos. With exports already reaching the Middle East and the US market on the horizon, Sarawak’s sago cookies are going global - one crisp bite at a time. For Hafidz, the rise of homegrown, heritage-based food is more than a trend. He noted that today’s health-conscious consumers are open to trying traditional ingredients like sago, especially when offered in a modern, convenient form. Beyond expanding his sago’s product line, Hafidz’s vision is to make Sarawak’s sago a household name across ASEAN and beyond. However, to achieve this, he believed a strong ecosystem is essential - one that includes supportive policies, accessible funding, and mentorship in product development, branding, and export readiness. Agencies like CRAUN, MARA, and INSKEN, he added, can play a vital role. “With the right ecosystem, we’re not just building businesses - we’re securing Sarawak’s food future while preserving our local heritage.”

To aspiring young entrepreneurs, Hafidz has a clear message: “Don’t underestimate the potential of niche, heritage-based industries like sago. There is room for creativity and value-add. With Borneo’s rich natural resources and cultural heritage, I truly believe that industries like sago could be part of Borneo’s next big economic wave.”



Figure 2: Sago Gluten-free cookies making headlines (Source: Sarawak Tribune, 10 March 2025)

THE BRAINS-AND-BRAWN PARADOX: RETHINKING AGRO-FOOD FUTURES

Today, modern agriculture is not just about physical labour anymore. Brains and strategy matter just as much as brawn. Technologies like drones, GPS mapping, etc., require scientific comprehension. Even at the farm level, operating and maintaining such tools calls for agro-tech-savvy minds.

In parallel, the agro-food sector is moving into science-led frontiers. Foods are now being formulated not just for energy, but also to support health and prevent diseases. Advances in tissue culture and plant biotechnology are enabling the production

of high- yield planting materials, while agro-waste is being transformed into value-added products and renewable energy. Climate change adds another dimension as regenerative agriculture gains more traction, strategically positioning the agro-food sector at the heart of the emerging carbon economy - far from being outdated.

All of this calls for a serious mindset shift - Agriculture is not a fallback when everything else fails. It is a nexus where science, business, and sustainability intersect. It is no longer about choosing between books and boots - it is about embedding both to unlock the full power of land, culture, and innovation.

PAINTING THE PICTURE

To truly drive the transformation in agro-food sector, we must first change how the field is portrayed and articulated. In many early education materials, agriculture is still visualised through traditional imagery of farmers in straw hats, working with a cangkul under the blazing sun. While this holds some truth, it barely scratches the surface of what the sector looks like today. Both the image and narrative now need reframing - to reflect AI-powered smart farms, biotech and food labs advancing the future of nutrition, and micro-factories sustainably and innovatively monetising agro-wastes.

To vibe with the next generation, we need to update both visuals and mindset. Agro-food is not just about muddy boots anymore; it is going through a major glow-up. In Gen Z terms, *it's giving sigma energy, serious drip, and a whole lot of purpose. It totally slays - no cap!*

Wedjohn and Hafidz represent the future of Borneo’s agro-food landscape, especially in Sarawak. What is seen as a “sunset industry” can be reimagined through their journeys. They show that tradition, when paired with the right mindset, tools, and support, can propel Sarawak’s agro-food sector forward toward a future that is thriving, sustainable, and proudly homegrown.



Figure 3: Naturally gluten-free, sago flour also gives the cookies a light, crisp bite that customer enjoy. Currently available in three flavours: Oatmeal, Chocolate and Matcha.

THE RENEWAL OF OIL PALM PLANTATIONS: DIGGING DEEP INTO PEAT CHEMISTRY

Jacqueline Ratai, Nur Azima Busman, Nicodemus Ujih Michael Brenden, Amelia Jakob, and Faustina E. Sangok

Chemistry Research Division, Sarawak Tropical Peat Research Institute, Kota Samarahan

INTRODUCTION

The Malaysian oil palm industry is a cornerstone of the national economy, contributing substantially to Gross Domestic Product (GDP), boosting export earnings, and providing widespread employment opportunities. However, despite its economic importance, the sector faces significant challenges, including environmental concerns, production inefficiencies, market volatility, and social impacts. Oil palm trees are most productive in the early years of their life cycle. After 20-25 years, they grow too tall for efficient harvesting, and yields begin to decline. At this stage, replanting is essential to sustain productivity, with new palms established on the same lands where earlier cycles have reached the end of their economic lifespan (Murphy et al., 2021). Since large-scale industrial oil palm plantations in Malaysia were widely developed in the early 2000s, many estates are now approaching this critical replanting phase. It is estimated that more than one million hectares will require clearing and replanting in the coming years (Snaddon et al., 2013).

WHY REPLANTING MATTERS

Replanting offers a land-efficient strategy to maintain or even increase yields without resorting to deforestation or expansion into untouched ecosystems, which would otherwise pose greater environmental risks. This approach aligns with the global sustainability agenda, particularly *SDG 13: Climate Action* and *SDG 15: Life on Land*, by reducing pressure on natural forests and safeguarding biodiversity. However, replanting also presents new challenges. The long-term use of land during the first oil palm cycle

may alter soil properties, potentially reducing soil health and affecting the growth and productivity of newly planted palms. Despite its importance, the long-term impacts of oil palm replanting on soil quality and ecosystem function remain insufficiently understood (Lim et al., 2021). Addressing these knowledge gaps is crucial to ensure that replanting sustains productivity while minimising environmental risks, especially within fragile tropical peatland ecosystems.

THE PEAT ENIGMA: EFFECT ON SOIL HEALTH

One of the most critical issues in replanting is soil health. The first cycle of oil palms often benefits from pristine or minimally disturbed soil conditions. However, decades of monoculture, frequent fertiliser use, and mechanical harvesting can deplete nutrients and alter soil microbial communities. Studies have shown reductions in organic matter content, increased soil acidity, and decreased biological activity after successive cycles (Gaynor et al., 2020). These effects may ultimately influence yields and sustainability unless addressed through careful soil management practices. The impacts can be even more significant in peatland areas, where replanting must be guided by careful planning and sound agricultural practices to minimise further soil degradation (Husnain et al., 2014).

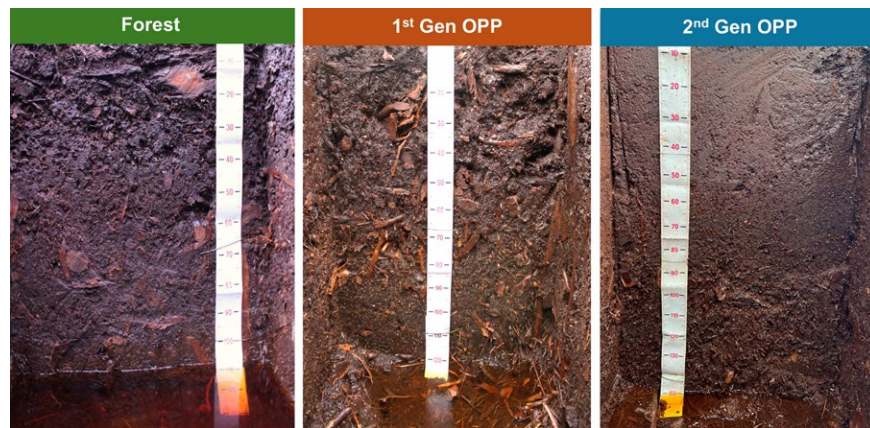


Figure 1: Peat profile at the study site (Ratai et al., 2025)



Figure 2: Soil column experimental set-up in the laboratory (Ratai et al., 2025).

UNSEEN SHIFT: UNDERSTANDING CHEMICAL CHANGES IN PEAT SOILS

Peat soils are unique because of their high organic matter content, formed over thousands of years under waterlogged conditions. In such environments, plant residues remain undecomposed, gradually forming deep peat layers. When drainage occurs, oxygen becomes available, enabling microbes to decompose organic matter. Over 20-25 years of oil palm use, the quality of this organic matter gradually changes. Since soil quality is closely linked to organic matter, it is important to monitor these changes over time. Using ATR-FTIR spectroscopy, shifts in chemical composition can be detected by identifying specific chemical bonds and functional groups (Bartos et al., 2020). Peat soils replanted with a second oil palm cycle often show a decline in compounds linked to fresh, decomposable materials like sugars and simple plant residues. At the same time, more resistant compounds, such as lignin and aromatic structures, which are harder to break down, tend to accumulate (Ratai et al., 2024). Lehmann et al. (2007) and Hoo et al. (2021) note that soil degradation may progress more slowly, but the soil still loses some of its inherent natural quality. These subtle changes in soil quality eventually affect its function. Understanding these transformations is essential for the sustainable peatland management.

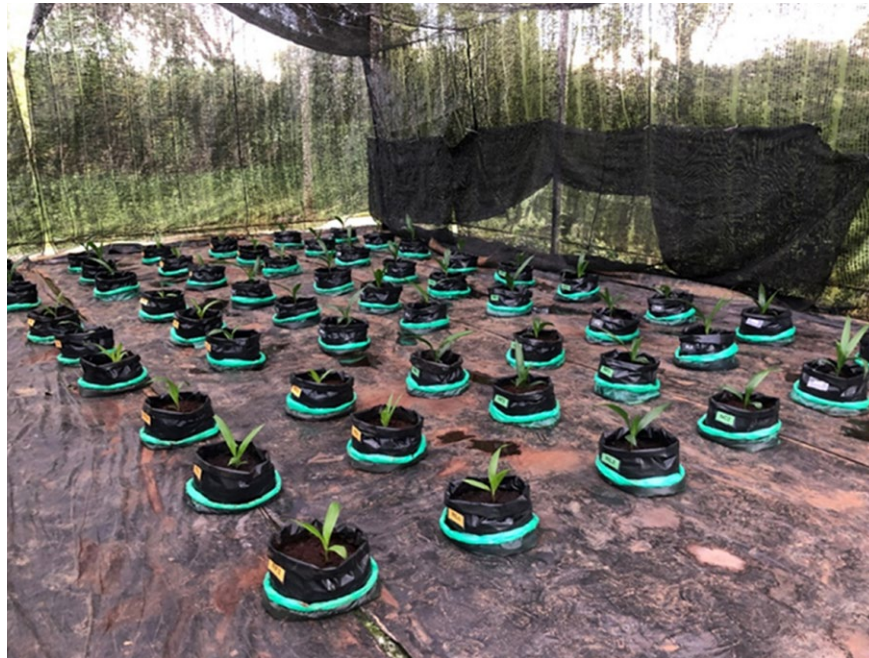


Figure 3: A polybag experiment under rain shelter environment (Ratai et al., 2025).

NUTRIENT LEACHING IN PEATLANDS

Replanting also alters nutrient dynamics. In the first cycle, peat soils are highly porous, with a looser structure and more open pore spaces, which accelerates leaching of water and nutrients such as nitrogen, phosphorus, and magnesium. Because the soil is less decomposed, it does not retain nutrients very well, making them more prone to being washed away during rainfall. In the second cycle, years of planting and replanting make the soil denser and more compact. This condition slows water movement and helps retain nutrients, reducing nutrient loss through leaching.

STRONGER SEEDLINGS' ROOTS, BETTER GROWTH

Seedlings grown in second-cycle peat soils showed higher root dry weight compared to those in first-cycle soils, highlighting the crucial role of root growth for early plant vigor (Ratai et al., 2025; Wang et al., 2016). Although root growth was better in replanted peat soils, aboveground traits such as plant height, stem diameter, leaf area, and shoot dry weight showed no significant differences between the two soil types. These aboveground

characteristics may take longer to manifest and were not fully expressed within the short duration of this study. Therefore, conducting field experiments is recommended to further validate these findings.

The addition of lime and fertiliser could further improved growth. Liming effectively reduced soil acidity, creating a more balanced environment for nutrient availability. This enhanced fertiliser uptake and encouraged stronger root development. Fertiliser applications provide essential nutrients such as nitrogen, phosphorus, and potassium, which are vital during early growth. When combined, lime and fertiliser produce positive responses both below ground and above ground, with improvements in root growth, leaf development, dry matter production, and photosynthetic efficiency. Together, these amendments enhanced soil health and supported more resilient seedling performance, particularly in degraded or previously planted peat soils.

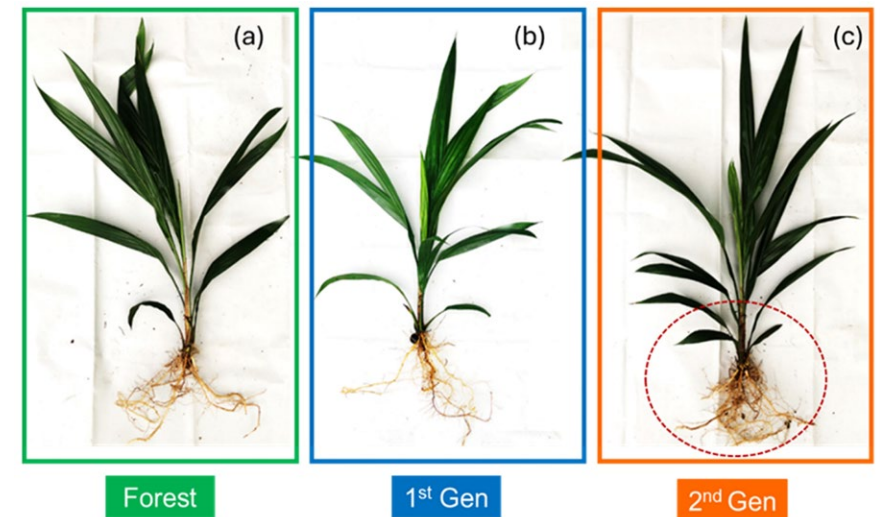


Figure 4: Seedlings grown in the soil of the 2nd Gen indicate a more extensive and branched root system, possibly supporting better nutrient uptake (Ratai et al., 2025).

PEATLANDS AND CARBON: A GLOBAL CLIMATE CHALLENGE

Peatlands store immense amounts of carbon, making them among the world's most carbon-rich ecosystems. When peatlands are drained, they are exposed to oxygen, which accelerates organic matter decomposition and releases large amounts of carbon dioxide. During the first cycle, prolonged aerobic conditions decompose the more labile organic matter. In the second cycle, soils may contain more resistant compounds, such as lignin, making them less prone to rapid decomposition. This may result in lower CO₂ emissions

during replanting. Nonetheless, carbon emissions are also strongly influenced by land management practices, emphasising the need for sustainable approaches when managing peatland carbon dynamics (Tan et al., 2021).

CONCLUSION

Replanting oil palm on tropical peatlands involves balancing crop productivity, environmental protection, and long-term land use. While much is still unknown about the complexity of these ecosystems, future progress depends on advancing our knowledge and implementing management practices that enhance both the sustainability and ecological resilience of these important landscapes.

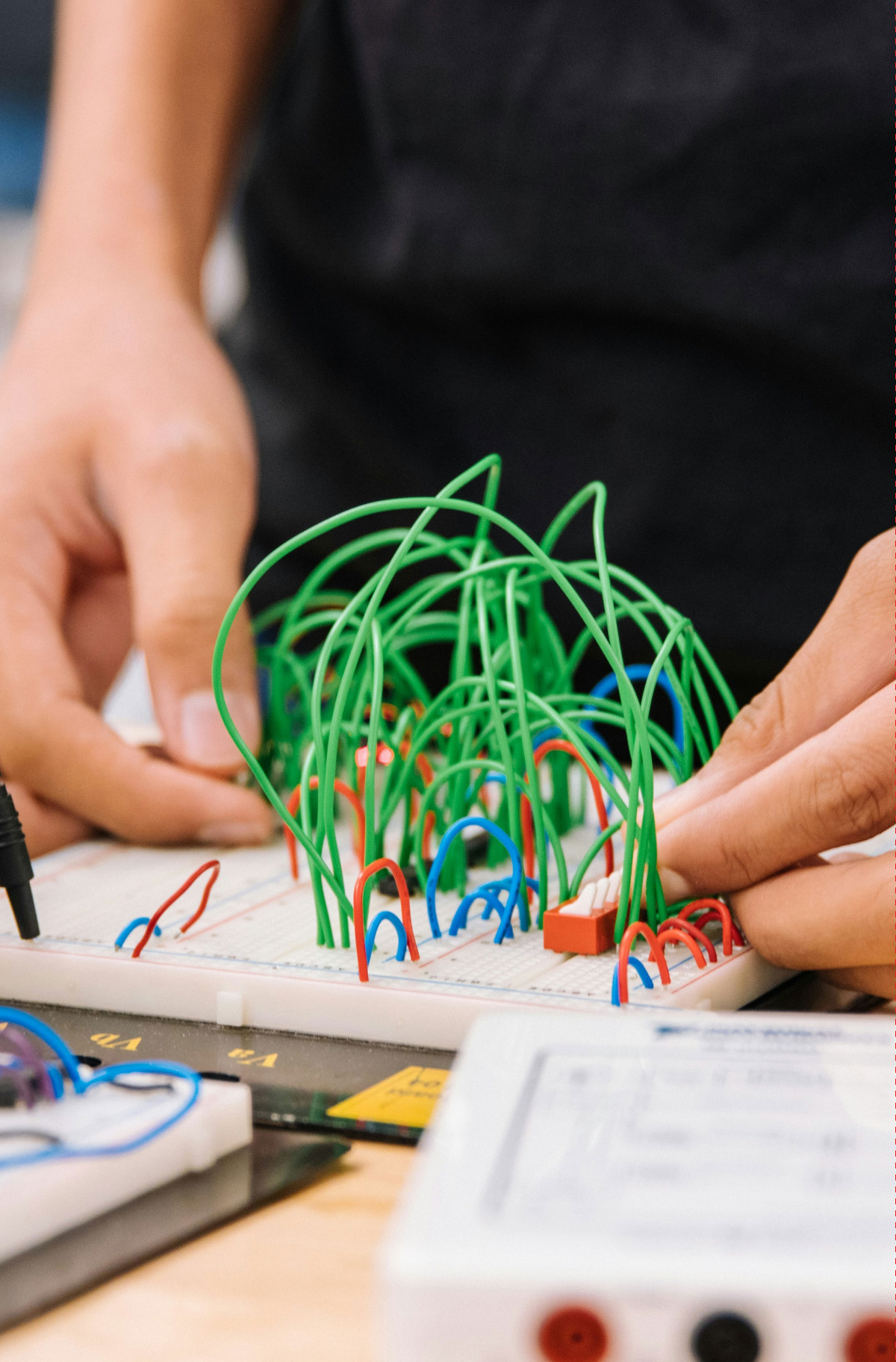
ACKNOWLEDGEMENT

The author wishes to acknowledge the members of the Sarawak Tropical Peat Research Institute particularly the Chemistry Research Division for their valuable support in fieldwork and technical assistance.

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FUTURE OF BORNEO: NURTURING STEM-READY GENERATION

Eve Sanedi and David Wee Hong-Sheng

Sarawak Research and Development Council & Sarawak Science Centre

Sarawak is paving the way for a future powered by knowledge, innovation, and inclusivity, one where the next generation is equipped to lead Borneo into a high-tech, high-income era. Central to this vision are initiatives aimed at cultivating young minds in Science, Technology, Engineering, and Mathematics (STEM). Among them, the **SRDC BrightSparx Grant** and the **STEM Catalyst Programme** stand out as key drivers in shaping the future of STEM in Sarawak.

At the heart of these efforts lies a simple but powerful belief: *that talent exists everywhere, even in the most remote corners of Borneo, and with the right opportunities, guidance, and exposure, these young minds can rise to meet global challenges.*

SRDC BRIGHTSPARX: SUPPORTING YOUNG INNOVATORS IN STEM

First introduced in 2019, the 3rd edition of the **Sarawak Research and Development Council's (SRDC) BrightSparx Grant** is launched this year, continuing its role as a platform to spark innovation among school pupils. The grant offers RM5,000 to support primary and secondary school students in transforming their creative ideas, grounded in STEM principles, into tangible solutions.

Co-organised with the Sarawak Science Centre, this program is part of a broader effort to instil critical thinking and inquisitive research mindsets among Sarawak's young learners. It encourages projects related to real-world challenges and opportunities, especially those aligned with Sarawak's Post COVID-19 Development Strategy (PCDS) 2030, which emphasises societal and economic benefit.

Beyond funding, participants receive mentorship from professionals in academia and industry to refine and prototype their ideas. The programme is open to primary and secondary school teams of up to three pupils and one teacher. A total of 100 teams will receive the SRDC BrightSparx grant to carry out their projects, with 20 finalists selected to present at the bi-annual SRDC Symposium. This final event, known

as the Premier's BrightSparx Innovation Award (PBSIA), honours the best-developed idea. The top team will also have their names engraved on the PBSIA rolling trophy.

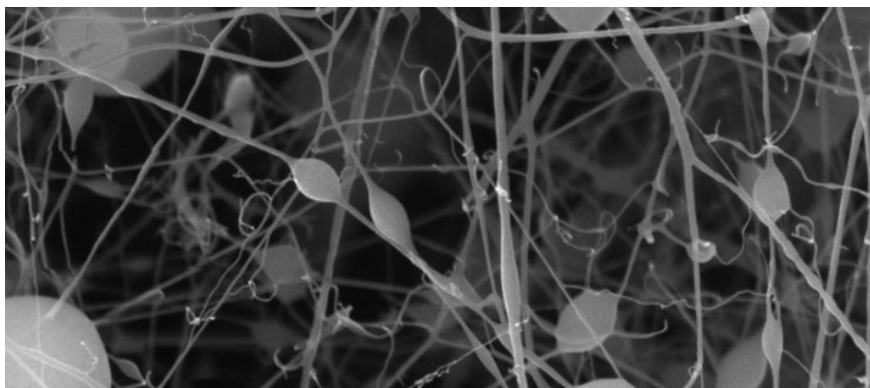
At its core, BrightSparx reflects the belief that ideas born in the classrooms of Sarawak, even in remote areas, can one day change the world. As SRDC General Manager, Ts. Dr. Peter Morin Nissom, puts it:

"At the heart of SRDC, BrightSparx is a firm conviction that even ideas born in a classroom in a remote village in Sarawak might one day shape the world. However, an idea alone is not sufficient to create impact. It must be supported by a deep understanding of STEM and methodical research and development approaches."

This belief is already taking root. Past BrightSparx winners have tackled real-world issues which ranges from using Oil Palm Shell as Aggregates in the construction world to developing eco-friendly nanofiber wound dressings from biomass waste for improved medical treatment. These are not just science fair projects. They are early sparks of innovation and some of them hold serious potential for scalability and real-world application.



St. Joseph Private School students casting concrete with oil palm shell aggregates.



Microscopic image of prawn shell nanofibers created by SMK Batu Lintang students for wound healing.

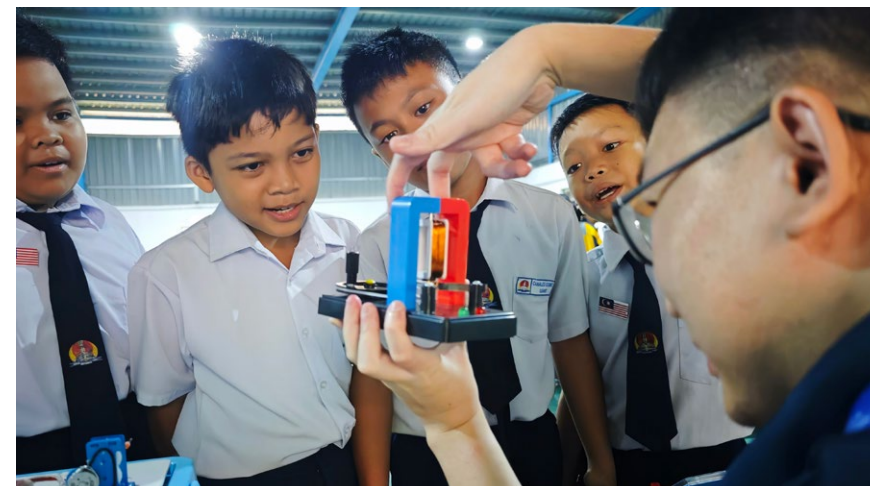
STEM CATALYST PROGRAMME: BRIDGING THE URBAN-RURAL DIVIDE

Despite the rapidly evolving technological landscape, STEM uptake remains a challenge in Malaysia. Only 50.8% of SPM students are enrolled in STEM, falling short of the 60% target outlined in PCDS 2030. To address this gap, the STEM Catalyst Programme was launched in 2024 which is a part of a coordinated effort alongside other initiatives from the Ministry of Education, Innovation, and Talent Development (MEITD) to ignite student interest in STEM from a young age.

The programme is an interactive educational carnival that evolved from the Raspberry Pi distribution programme initiated in 2021. It now features a broader scope with hands-on exhibits aimed at simplifying STEM concepts and creating an engaging learning environment. The goal is to catalyse curiosity, especially among students in rural Sarawak, so they can see themselves as future scientists, engineers, and innovators.

Themes covered in the programme include:

1. **Implementation of Raspberry Pi** – a cost effective, portable, low-power miniature computer – in various applications.
2. **Sensors** – its role in automation, environmental monitoring, and smart systems.
3. **Robotics** – showcases the importance of mechanical engineering concepts, and how sensors are integrated in automation alongside computer programming.
4. **Programming** – encourages logical thinking, problem solving, and creativity in students.
5. **Energy** – introduces the concept of clean energy, with an emphasis on hydrogen fuel cell technology (as opposed to combustion technology).
6. **Physics** – concept of weight distribution involving pulleys and hydraulics, electricity generation, and the physics behind drones (ever wonder why they usually have 4 propellers?).



Students learning how motion creates electricity using magnets and wires.

Bringing these abstract concepts to life for young learners, especially in primary schools, is no small feat. Concepts like hydrogen fuel cell technology are often laden with technical jargon. Yet, facilitators simplify them without losing meaning such as linking hydrogen to air pollution which helps students connect clean energy to real-life issues like smog from car exhaust.



Students interacting with the solar panel exhibit

IMPACT ON RURAL COMMUNITIES

One of the programme's defining features is its ability to reach students who have never before seen a robot or held a computer. Through a decentralised format, a school from each district is appointed as a host, in which students from nearby schools are ferried in by bus to participate in the programme. For many, it is their first exposure to digital tools, sensors, and coding which are things often taken for granted in urban centres.

BEYOND THE STUDENTS: EMPOWERING EDUCATORS AND VOLUNTEERS

These initiatives don't only impact students but they also uplift university student volunteers who act as mentors and facilitators. Many refine their own communication

and technical skills while giving back to their community and state. As the late physicist Richard Feynman once said,

"If you can't explain something in simple terms, you don't understand it."

Volunteers reported feeling more confident, more connected to the community, and more prepared for professional life.



SK St. Patrick students completing a circuit in the Human Battery exhibit.

WHY IT MATTERS: STEM FOR THE FUTURE OF BORNEO

Borneo faces unique challenges such as geography, infrastructure gaps, and rapid socio-economic transformation. Despite these challenges, Borneo holds vast potential especially in natural resources, biodiversity, and emerging industries like hydrogen economy and clean tech.

To capitalise on these, Sarawak must develop a STEM-competent workforce that can support research, innovation, and high-value industries. The seeds planted through SRDC's BrightSparx and the STEM Catalyst Programme may take time to grow, but they are crucial investments in Sarawak's long-term resilience and prosperity.

These programmes are not just about inspiring individuals. They are about shifting a collective mindset in making STEM relatable, accessible, and ultimately desirable.

A COLLABORATIVE EFFORT

The success of these programmes is underpinned by partnerships across sectors. The STEM Catalyst Programme 2025 is hosted by Ministry of Education, Innovation, and Talent Development (MEITD) and Sarawak Skills, supported by Sarawak Research and Development Council (SRDC), Sarawak Science Centre (SSCiEX), University Technology Sarawak (UTS), the British High Commission, UNICEF, and the Rolf Schnyder Foundation.

Meanwhile, the SRDC BrightSparx Grant continues to provide a structured pathway for school teams to transform their ideas into real-world solutions, culminating in their showcase at the SRDC bi-annual Symposium.

BUILDING A BRIGHTER TOMORROW

The **Future of Borneo** lies not in concrete or skyscrapers, but in the minds of its people, who are young, curious, and determined. As Sarawak strengthens its push towards becoming a high-income state by 2030, efforts like the SRDC BrightSparx and the STEM Catalyst Programme serve as crucial pillars.

The message behind these programmes is clear: *STEM is for everyone, regardless of background, geography, or income.* With continued support and collaboration, these programmes ensure that Sarawak's journey towards innovation is inclusive, impactful, and sustainable.

By moving forward together, we can shape a Borneo that is not only advanced, but also fair and fills our community with hope.

Sarawak Maju Makmur.



CLEAN ENERGY IN ACTION: THE SMART SOLAR HOUSE AND SDG 7

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INTRODUCTION

The Smart Solar House is a pioneering initiative developed through the strategic collaboration between Sarawak Skills and Neuto Energy Sdn. Bhd. Designed as a sustainable learning and innovation hub, the house demonstrates practical applications of renewable energy while providing educational, research, and community engagement opportunities. This article explores the project's objectives, technical composition, environmental impact, and broader implications for workforce development and energy sustainability. The initiative underscores the potential of institutional-industry partnerships in driving green innovation and preparing future talent for the demands of a low-carbon economy.

Global efforts to mitigate climate change have accelerated the shift towards renewable energy and sustainable development. Within this context, the Smart Solar House represents a model initiative that integrates solar technology with education, research, and community engagement. Aligned with SDG 7 (Affordable and Clean Energy), the project demonstrates how collaborative efforts between academia and industry can deliver practical solutions to real-world challenges while promoting wider adoption of clean and sustainable energy.

EDUCATIONAL AND RESEARCH OBJECTIVES

Practical Learning for Students

One of the core purposes of the Smart Solar House is to serve as a hands-on educational platform. Students from technical and vocational backgrounds, particularly in renewable energy and electrical engineering programmes, engage directly with operational solar energy systems. This experiential learning approach bridges the gap between theoretical

instruction and applied knowledge, fostering skill development aligned with industry expectations.

Research and Development

The facility also supports academic research in areas such as photovoltaic energy production, battery storage optimisation, and home energy management. Both students and staff members are encouraged to use the space for experimental projects and data-driven inquiry, contributing to the growing body of knowledge in sustainable energy systems.

TECHNICAL FEATURES OF THE SMART SOLAR HOUSE

The Smart Solar House makes use of several green technologies to create a reliable and sustainable energy system. Its 28 solar panels can generate around 2,555 kWh of electricity each year. The energy collected is then converted by an inverter from direct current (DC) into alternating current (AC), which is what we normally use at home. To keep the power running even when there's little sunlight, the house is also equipped with a 30 kWh lithium battery bank that stores extra energy for later use.

At the core of the house is a solar photovoltaic system that harnesses sunlight to generate electricity, significantly reducing dependency on the grid and lowering utility costs. This energy is intelligently managed through a smart energy management system, which monitors production, consumption, and storage often using battery backups to ensure power is available even during outages. Paired with automation technologies such as KNX Home Automation, the Smart Solar House system can be automated and accessed remotely.

In addition to energy efficiency, the Smart Solar House is designed with convenience and safety in mind. It offers remote control of lighting, temperature, and security systems via smartphone apps, allowing homeowners to manage their homes anytime, anywhere. Automated blinds, smart lighting scenes, and real-time environmental sensors help maintain comfort while conserving energy. Security is enhanced through integration with mobile surveillance systems such as EMS Mobile Security Surveillance, which provides live video monitoring, motion alerts, and remote access to CCTV feeds. This allows homeowners to receive instant alerts and view footage in real-time, ensuring peace of mind whether they are at home or away. Together, these systems create a sustainable, intelligent, and secure living environment reflecting the future of modern, eco-conscious living.

ENVIRONMENTAL BENEFITS

A significant feature of the Smart Solar House is its positive environmental impact. It achieves an estimated annual reduction of 127.75kg of CO₂, contributing to national and international efforts to lower greenhouse gas emissions.

COMMUNITY ENGAGEMENT AND INDUSTRY COLLABORATION

Public Outreach

The project fosters environmental literacy among local communities by hosting workshops, educational tours, and public demonstrations. These outreach efforts are aimed at cultivating a culture of sustainability and encouraging community adoption of renewable technologies.

Industry-Education Synergy

The collaboration between Sarawak Skills and Neuto Energy Sdn. Bhd. exemplifies an effective education-industry partnership. While Sarawak Skills provides the educational infrastructure and student body, Neuto Energy contributes industry-grade technology and technical expertise. This synergy ensures the integration of up-to-date industry standards into educational programming, including co-developed training modules and equipment donations.

FUTURE DIRECTIONS OF THE SMART SOLAR HOUSE PROJECT

The Smart Solar House continues to evolve as a complete model for green infrastructure, with future developments including the incorporation of an electric vehicle (EV) charging station to connect clean energy generation with sustainable transportation. It represents a successful fusion of technology, education, and sustainability, serving as both a functional model of energy-efficient living and a scalable framework for workforce development and green innovation. Through strategic collaboration, it stands as a vital catalyst for empowering students and communities in the transition to a sustainable future, especially as the demand for renewable energy expertise continues to grow.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the contributions of Sarawak Skills and Neuto Energy Sdn. Bhd. for their vision and collaborative efforts in developing the Smart Solar House project.

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Figure 1: Exterior View of the Smart Solar House.



Figure 2: Educational Display Inside the Smart Solar House.



Figure 3: Flow of the PV Solar System and Schematic Drawing (Left Panel - "Flow of the PV Solar System" and Right Panel - "Schematic Drawing of the PV Solar System").



Figure 4: Physical Setup of the PV Solar System Components.



CENTEXS AEROSPACE ACADEMY: POWERING THE FUTURE OF AEROSPACE INNOVATION IN SARAWAK

Dr. Dayang Hanani binti Abang Ibrahim and Shiraz Yasmine binti Khir

Aerospace, Digital and Green Energy Academy
Centre for Technology Excellence Sarawak (CENTEXS)



As Sarawak sets its sights on becoming a regional leader in high-technology industries, the aerospace sector has been identified as a key pillar of the state's Post COVID-19 Development Strategy (PCDS) 2030. With its strategic equatorial location, rising global demand for aerospace services, and a clear focus on economic diversification, Sarawak is actively building a robust competitive aerospace ecosystem.

Complementing this vision is the AirBorne initiative, which aims to enhance regional air connectivity and promote eco-tourism by linking remote communities and key destinations across Borneo. More than just a transport solution, AirBorne is part

of Sarawak's broader ambition to establish itself as an aviation hub for Borneo and a gateway to the ASEAN region. Together, these efforts reflect a unified strategy, focused on developing local talent, strengthening aerospace infrastructure, and integrating air mobility solutions, to position Sarawak at the forefront of Southeast Asia's aviation and aerospace landscape.

THE MOTIVATION: WHY AEROSPACE, WHY SARAWAK?

Sarawak's push into the aerospace sector is both strategic and forward-looking, driven by its unique geographical advantage near the equator, making it an ideal location for future satellite launch operations. The aerospace industry has been identified as a key pillar under the state's Post COVID-19 Development Strategy (PCDS) 2030, serving as a pathway to move up the economic value chain. Beyond economic goals, this initiative also focuses on empowering local youth through industry based technical and technology training, equipping them with in-demand skills and enhancing their employability in high-tech sectors. As aerospace technologies become increasingly critical for communication, defense, and transportation, building local capabilities also supports Sarawak's goal of achieving greater technological sovereignty and long-term resilience.

At the same time, AirBorneo is poised to strengthen regional connectivity and promote eco-tourism across Borneo by connecting remote communities with major tourist destinations in Sarawak and surrounding regions. The Sarawak government plans to transform AirBorneo into a full-service airline, positioning the state as a key aviation hub for Borneo and a strategic entry point to the ASEAN market. This development is also expected to create new employment opportunities within the aerospace industry.

CHALLENGES ON THE HORIZON

Despite its potential, the aerospace sector faces significant challenges. One of the key issues is the talent shortage, as the global demand for aerospace expertise continues to grow while the pool of certified and skilled professionals remains limited—a gap that CENTEXS aims to address through targeted training programmes. Another challenge lies in the capital-intensive nature of infrastructure development, as the sector requires substantial investment in advanced technology, specialised facilities, and regulatory compliance. Beyond workforce development, there is also the issue of industry readiness, where building a sustainable aerospace ecosystem depends not only on training talent but also on ensuring that local industries, suppliers, and Research and Development (R&D) institutions are adequately prepared to scale and support growth.



LAUNCHING A NEW ERA: CENTEXS AEROSPACE ACADEMY

At the forefront of this transformation is the Centre for Technology Excellence Sarawak (CENTEXS), which has positioned itself as a vital enabler of talent development and innovation. In 8th October 2024, CENTEXS launched its inaugural Aerospace Academy, a landmark initiative officially officiated by The Right Honourable Datuk Patinggi Tan Sri (Dr) Abang Haji Abdul Rahman Zohari, Premier of Sarawak. Through its establishment, this academy serves as a catalyst for building an industry-aligned, future-ready talent pipeline to meet growing global and regional demand in aerospace services and manufacturing.



The first cohort enrolled in highly specialised training programmes including:

Certificate in Aircraft Maintenance Engineering (Helicopter Turbine) (22 Months)

Certificate in Aerospace Sheet Metal (14.5 Months)



Certificate in Aircraft Maintenance Engineering (Helicopter Turbine) (22 Months)

Certificate in Aerospace Machining Operation (11 Months)

Certificate in Aircraft Maintenance Engineering (Aeroplane Turbine) (22 Months)

Certificate in Aerospace Computer Numerical Control (Cnc) Machining (11 Months)



Currently entering its second cohort, the academy has attracted growing interest, with the next intake planned for October 2025. The training programmes are designed to deliver job-ready, hands-on training, preparing graduates for immediate entry into the aerospace workforce or further upskilling in advanced technical fields.

STRATEGIC INDUSTRY PARTNERSHIP

CENTEXS works in close collaboration with AIROD Aviation Design Centre Sdn Bhd (ADC) Sdn. Bhd., an established player under the National Aerospace and Defence Industries (NADI) group. This partnership ensures that classroom learning is tightly integrated with real-world industry exposure, particularly in aircraft component manufacturing and Maintenance, Repair, and Overhaul (MRO) operations.



EXPANDING HORIZONS AND ADVANCING THE AEROSPACE ECOSYSTEM

As part of its continuous commitment to develop a well-rounded aerospace workforce, CENTEXS is actively expanding its training portfolio, with new training programmes in the pipeline to support both technical and operational roles across the aviation industry. These initiatives are being developed in collaboration with potential national and international partners that aims at equipping Sarawak's youth with the necessary competencies to serve in various segments of the aerospace services sector.

Moving ahead, these efforts not only address growing industry demand but also reflect the state's long-term vision of becoming a recognised aerospace hub in Southeast Asia. With the support of strategic partnerships and infrastructure development such as the proposed Aerospace Industrial Park and Aerotropolis, CENTEXS continues to play a pivotal role in shaping the human capital required to power Sarawak's entry into the global aerospace arena.



CENTEXS AEROSPACE ACADEMY DUA: A VISION FOR SPACE

Unveiled during CENTEXS' 9th Convocation Ceremony on the 26th February 2025, the Aerospace Academy Dua represents CENTEXS' bold step into space innovation and rocketry. With a focus on launch vehicle technology, satellite systems, and space research, this second phase of the academy envisions Sarawak as a launchpad for Southeast Asia's entry into space technology.



The Academy Dua is in active development, with collaborative R&D projects and strategic discussions ongoing with key players from aerospace, space, and defense sectors, paving the way for high-impact innovation.

CENTEXS - i-CATS COLLABORATION: BUILDING A HOLISTIC TALENT PIPELINE

To strengthen the talent pipeline further, CENTEXS works in close synergy with i-CATS University College, particularly in academic progression and research. This collaboration bridges technical training and tertiary education, allowing trainees to pursue higher qualifications while also engaging in R&D and innovation-driven projects related to aerospace electronics, and AI in aviation. CENTEXS has accelerated its development efforts, in collaboration with i-CATS University College under the Aerospace Hub at CENTEXS

Lundu. This initiative includes providing aerospace related technical and professional certification training programmes for school leavers and post-degree trainees by CENTEXS, whereas i-CATS will provide aerospace degree and post-graduates programmes (Master and PhD), marking a significant advancement in this field. Together, CENTEXS and i-CATS are leveraging their strengths to offer a comprehensive talent development initiative in the aerospace industry, helping to build a pipeline of skilled technicians and professionals to meet the demands of the aerospace industry.

SHAPING THE FUTURE OF BORNEO THROUGH AEROSPACE

At its core, CENTEXS' aerospace efforts go beyond technical training. It is about empowering a new generation, unlocking high-tech economic opportunities, and placing Sarawak, and Borneo, on the global aerospace map.

The journey has just begun and the direction is clear. Sarawak is charting a bold course to become a regional hub for aerospace training, R&D, and innovation. CENTEXS is leading that flight, hand in hand with the industry, academia, and the aspirations of the people.



SUBMARINE GROUNDWATER DISCHARGE (SGD) AS AN EMERGING AND NEEDED RESEARCH FOR MARINE ECOSYSTEM SUSTAINABILITY

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Submarine groundwater discharge (SGD) is a complementary process generally observed in coastal regions worldwide, which poses different threats to the coastal aquifers and marine ecosystems including the coastal communities (Sajeev et al., 2023). SGD releases a variety of pollutants into the ocean, which has a negative impact on coastal ecosystems. Through SGD, a variety of contaminants including nutrients, metals and also anthropogenic source of contaminants are reaching the marine environment. The marine ecology is particularly threatened by nutrient enrichment through SGD because it disturbs nutrient equilibria and encourages eutrophication.

The perception that the SGD flux was much smaller than that from rivers has led to a general neglect of the contribution of SGD to coastal waters. Recent research has highlighted that the biological and chemical processes occurring at the interface between the freshwater in the aquifer and the salt-water front frequently result in SGD having higher concentrations of nutrients, organics, radionuclides, trace metals, and nutrients (Luijendijk et al., 2020; Selvam et al., 2021; Chandrashekar and Manish, 2022). The chemical budgets of surface water ecosystems may be impacted by these fluxes.

An understanding of the impacts of SGD on the coastal system remains a very complex scientific problem. For example, excess nutrient addition by SGD to coastal waters can lead to harmful algal blooms, red tides, and damage to coral reefs. In the coastal city of Miri, growing industrial, agricultural, and urbanisation activities are causing a disproportionately high concentration of pollutants that may directly discharge into the rivers (Rakesh Roshan et al., 2022; Fiona Bassy et al., 2024), and subsequently end up in the coastal waters or infiltrate into the subsurface and therefore, requires the most attention. Thus, the evaluation of the nutrient and metal fluxes through SGD and their impact on the coastal ecosystem are needed to provide a baseline for coastal water quality monitoring and management.

Our research team from the Department of Applied Sciences, Curtin University, Malaysia and also from the international collaborative partner, Kuwait Institute for Scientific Research is current working on a multidisciplinary approach to study the SGD in Miri coastal environment. This research was funded by Curtin Malaysia Collaborative Research Scheme (CMCR). In this project, an HDR student is also working on the topic for her PhD. The current research is to investigate how the Miri beaches alter the contaminant flux flowing into the South China Sea using



Picture 1: Research team conducting resistivity survey in the field.

SGD estimation and hydrogeochemical analysis of coastal waters, including porewater, groundwater and seawater. This project is executed in various stages. In the first phase, secondary data such as rainfall, temperature and tides have been collected to understand the climatic variations in this region, which helps us to fix the sampling periods to cover the major monsoons. We have also used the remote sensing technique by interpreting the satellite imageries of sea surface temperature (SST), soil moisture and the drainage density in the Miri coast to identify the potential hot spots for the SGD for the further investigation. In addition to that, resistivity survey has been conducted along the Miri coast to understand the subsurface geology, water level and the groundwater movement (Picture 1).

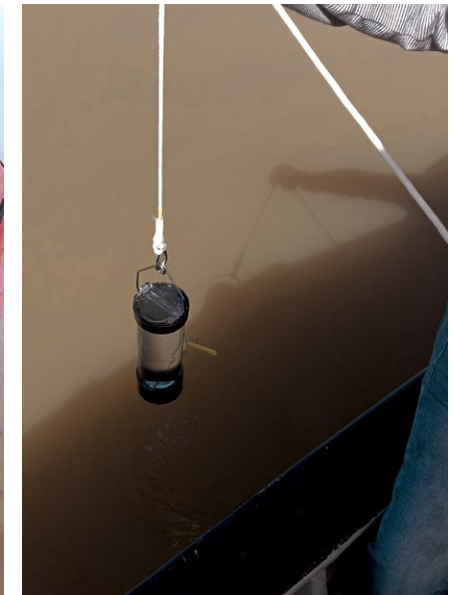
In the second phase, sampling strategy was designed to collect the samples in the identified hotspots. A total of 4 SGD hotspots were demarcated, and the samples have been collected in two different monsoons. In each hotspot, porewater samples have been collected in beaches at different depths using push point sampler (Picture 2). Seepage water samples adjacent to the beach was collected using seepage meter. Representative seawater samples were also collected using depth sampler. The collected samples were analysed for the physical parameters such as pH, electrical conductivity, total dissolved solids, dissolved oxygen, turbidity and salinity using portable meters in the field. In addition, radon concentration in water samples was measured in the field using Radon meter. In the

third phase, the collected samples were subjected to nutrients, major ions, trace metals and isotopes analyses in the laboratory. Finally, all the results will be integrated to estimate the contaminants flux added into the Miri coastal waters through SGD.

This is the first attempt to emphasise the attenuation of nutrients and trace metals in the Miri beaches of a tropical region in NW Borneo. The outcome of this research will help to estimate the contaminants (nutrients and metals) flux flowing into the Miri coastal ecosystem and its consequence on marine life and human health. This study could also be used to understand the present biogeochemical cycle in coastal waters. This research tries to address UN Sustainable Development Goals (SDGs) 14 (Life below water) with respect to restoration of water related ecosystems. This type of research is timely needed to understand the threat to aquatic life and maintain the marine ecosystem sustainably.



Picture 2: Research team collected porewater samples in the beaches.



Picture 3: Depth sampler to collect seawater samples at different depths.

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FROM POND TO PRODUCT: WATER HYACINTH A POTENTIAL REINFORCER

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INTRODUCTION

In recent years, the terms Environmental, Social, and Governance (ESG) and the United Nations Sustainable Development Goals (UNSDG) have gained widespread recognition and attention. These frameworks are part of a universal call to build a sustainable and equitable future for all. ESG is a set of non-financial metrics used to evaluate the sustainability and long-term values of companies, while the UNSDGs are a set of 17 goals to address global challenges, including poverty, hunger, and inequality [1].

Last year, Senator Markwayne Mullin, a member of the United States Senate, made a statement during a hearing of the Environment Committee, which gained significant attention, he said: “...everybody here depends on plastic as you sat...”. This instilled that the polymer materials were here to remain. It has been pointed out that the replacement of plastic will not only increase the cost of everything, but also disproportionately impact low-income people [2]. This highlights the necessity for polymer composites.

In principle, a composite is a combination of two or more different materials, consisting of a polymer matrix and added reinforcements, as shown in Fig 1. Fig. 2 displays the surface of a tested composite as viewed through a microscope. The reinforcement also acted as a filler, reducing the amount of polymer required.

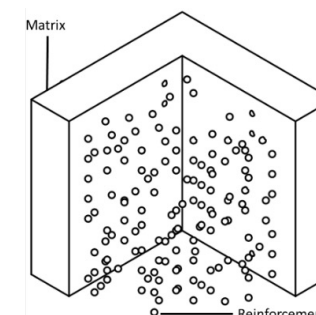


Figure 1: Matrix and Reinforcements in a Composite

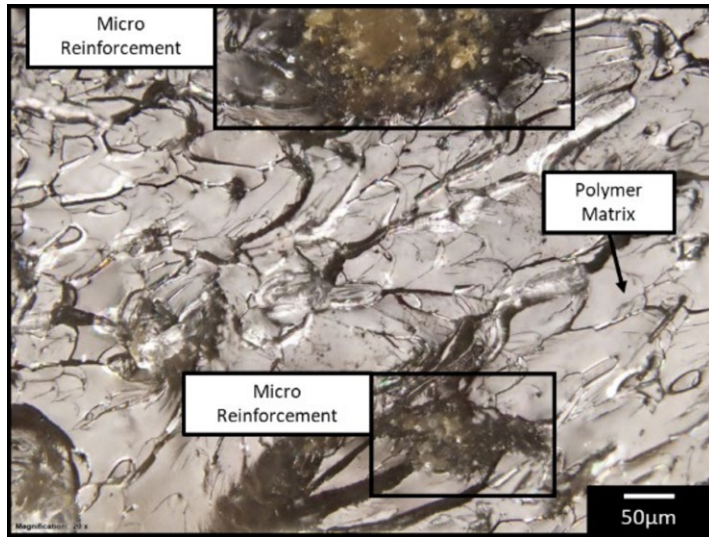


Figure 2: Surface of a Polymer Composite Through a Microscope.

WATER HYACINTH BACKGROUND

Water Hyacinth (WH) belongs to the *Pontederiaceae* family and is known to be taxonomically problematic [3]. The plants obtained within Miri displayed a similar appearance to those found in Africa and North America, as shown in Fig 3 and Fig 4. WH has been scientifically termed *Pontederia Crassipes* (previously known as *Eichhornia Crassipes*). However, WH is also known by many other names such as *Eichhornia Speciosa*, *Piaropus Carssipies*, *Eichhornia Crassicaulis*, *Heteranthera Formosa*, *Piaropus Mesomelas*, and *Pontederia Crassicaulis* [4,5].

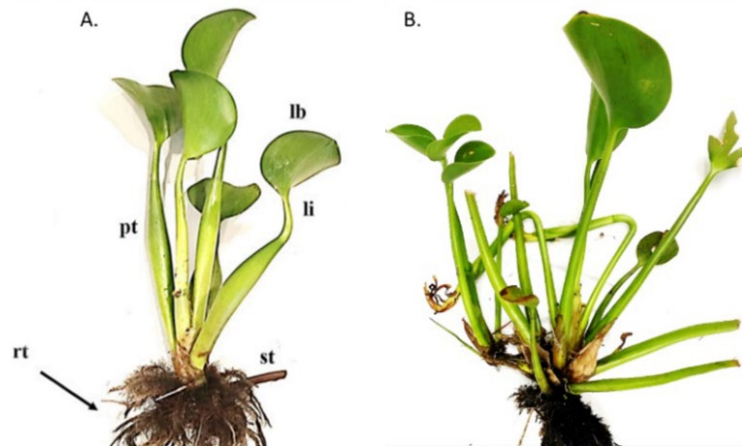


Figure 3: WH Plant (A: Lake Tana, Ethiopia [6], B: Lake Curtin-Senadin, Malaysia).



Figure 4: WH Flower (A: Florida, United States of America [7], B: Sarawak, Malaysia)

A single plant produces 28,000 tons of fresh biomass and 140 million daughter plants annually [8]. Owing to its high reproduction and widespread growth rate, it has caused ecological disruption and severe environmental and economic problems. It not only restricts water flow and deprives the water of oxygen [9] but also forms a thick mat of roots that obstructs water transportation [10]. Fig 5 illustrates the plant's encroachment on water bodies in Miri, Sarawak. Local news agencies have covered these issues [11-13]. Unfortunately, negative attitudes and lack of funding have proven to be the principal barriers to eradicating aquatic weeds from water bodies worldwide [14].



Figure 5: Water Bodies in Miri, Sarawak (A: Off Jalan University, B: Off Jalan Ilmu)

OPPORTUNITIES AND CURRENT PROCESS

The development of WH composites is in its early stages, as evidenced by the limited number of currently available publications. The period of WH development is still categorised as the acceleration period [15]. This suggests that the potential of this fiber has not yet been fully utilised and necessitates further evaluation.

Among the natural fibers available in Malaysia shown in Table 1, WH is among the highest concentration of cellulose and the lowest density. Furthermore, it is the only plant on the list that is not intentionally cultivated and has a relatively high cellulose content [5]. Notably, the incorporation of high cellulose content plays a crucial role in the development of mechanically robust materials, as cellulose possesses properties that enhance the overall strength of the composite [17], and the application of lower-density reinforcements has the potential to decrease the bulk density of the composite.

Table 1: Cellulose Content and Density of Natural Fibers in Malaysia.

Type of Fibers	Cellulose (%)	Density (g/cm ³)	Ref
Pineapple Leaf	67.12 - 83%	0.8 - 1.6	[18,19]
Water Hyacinth (Petiole)	65.4	> 0.837	[20,21]
Banana	60 - 65	1.35	[22,23]
Jute	58	1.3 - 1.46	[22,23]
Kenaf	56.81 - 79.30	1.2	[23,24]
Sugarcane Bagasse	55.2	0.91	[25,26]
Oil Palm Empty Fruit Bunch	43.3	1.1972	[27,28]
Bamboo	41.8	1.1	[29,30]
Coir	26.6	1.41	[31,32]

Fig. 6 illustrates the current processes involved in transforming collected WH plants into potentially suitable materials for composite development. These procedures involved separating the petiole, washing, cutting, milling, and sieving.

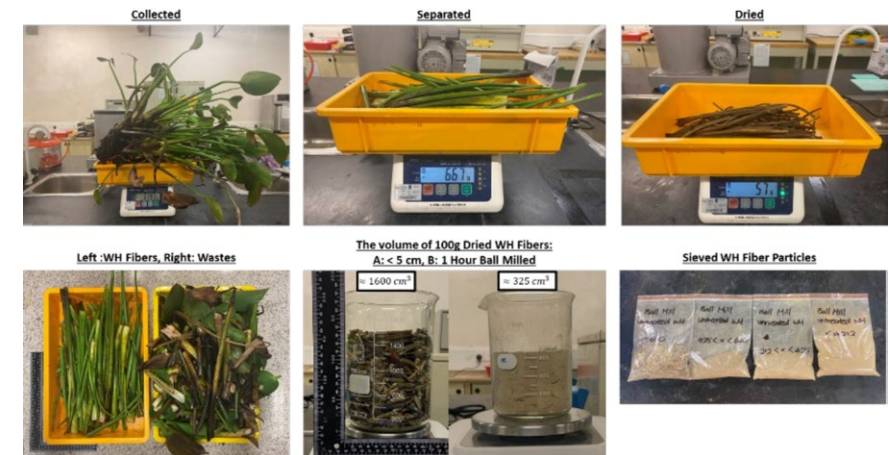


Figure 6: Transforming WH into Potential Reinforcements.

CHALLENGES IN COMPOSITE DEVELOPMENT

Polymer composites face several challenges for their effective use. One major hurdle is the even distribution of reinforcing materials within a polymer matrix [33]. Additionally, the lack of standardised specifications for polymer composite materials is a concern, as there is limited understanding of the required durability and performance over an extended period of time [34]. Furthermore, there is insufficient data in the areas of economic and scalability evaluations for the development of polymer composites, which is essential to align with the ESG theme.

CONCLUSION

Overall, the uncontrolled growth of WH poses a risk to the aquatic ecosystem of Sarawak. Nevertheless, there is a unique opportunity to harness these pests as a sustainable resource, without the need for active cultivation. Additional research is essential to fully realise the potential of this water-dwelling plant and its integration into the concepts of environmental, social, and governance (ESG) principles.

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DIGITAL TRANSFORMATION IN BORNEO'S VETERINARY SECTOR: AI AND TECHNOLOGY APPLICATIONS

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In Borneo, where farming, wildlife, and village life all exist side by side, keeping animals—and people—safe from disease is no small task. When a virus crosses species, it doesn't just threaten wildlife or livestock; it threatens lives and livelihoods. Rabies, swine fever, and bird flu are constant threats. As diseases move faster, traditional tracking methods cannot keep up. Fortunately, artificial intelligence (AI) and digital tools are changing the game, helping to predict outbreaks, monitor animals in real time, and support early intervention. This article looks at how technology is reshaping veterinary health in Borneo and what it could mean for the future of animals, communities, and conservation.

DEADLY VIRUSES ON OUR DOORSTEP

Borneo faces a range of animal health challenges that affect farm animals, pets, and wildlife alike. One of the most serious is African Swine Fever (ASF), a deadly virus affecting pigs. Around 41% of all ASF outbreaks in Malaysia have occurred in Borneo, causing major losses for pig farmers and wildlife conservation efforts (Li & Zheng 2025). Rabies is another ongoing threat, especially in rural areas where dog vaccination coverage remains patchy. Once symptoms appear in humans, the disease is almost always fatal, making early prevention through widespread vaccination critical (WOAH 2021; DVS Sarawak 2025a). Meanwhile, Highly Pathogenic Avian Influenza (HPAI), particularly the H5N1 strain, remains a serious concern for poultry farms due to its ability to spread rapidly and wipe out entire flocks. Although Borneo has not seen a major outbreak since 2018 (WOAH 2019), the threat persists, especially as global cases rise and migratory bird routes shift.

WHAT'S MAKING DISEASE TRACKING SO DIFFICULT?

Veterinary teams in Sarawak and Sabah have already made progress in disease control. Programs like the Kampung-to-Kampung Rabies Vaccination aim to create safer communities by vaccinating dogs, village by village (DVS Sarawak 2025b). At the research level, institutions like UNIMAS are advancing disease surveillance in wildlife populations, tracking pathogens from *Plasmodium knowlesi* in macaques to coronaviruses in bats (Tan et al. 2021). Beyond the laboratory, specialised organisations such as Orangutan Veterinary Aid (2025) and Sepilok Orangutan Rehabilitation Centre (2025) provide direct veterinary care that protects Borneo's most iconic species. Despite these promising efforts, gaps in digital technology and coordination continue to limit their effectiveness. One key issue is the lack of high-quality, centralised data. While some clinics and departments are adopting digital tools for record-keeping and diagnostics, many systems are still fragmented. This fragmentation limits the ability to develop reliable AI systems that depend on large, clean datasets to detect disease patterns and support early intervention (Folasole 2023). Another hurdle is the shortage of professionals skilled in AI and veterinary informatics. This often results in a reliance on external expertise and technologies. For example, many rural farmers struggle to operate advanced tools like drones due to lack of training or digital literacy (Rosnan & Yusof 2023). The digital divide in Borneo continues to limit access to tools that could otherwise improve disease monitoring.

TECH TO THE RESCUE: HOW AI AND DIGITAL TECHNOLOGIES CAN HELP

Despite these challenges, digital and AI-powered solutions are beginning to take shape. One promising innovation is the development of AI-based disease prediction models, which can forecast outbreaks by analysing historical data such as infection rates, geographic spread, and seasonality. These models can help veterinarians and farmers act early, reducing the severity of outbreaks. For example, Ryu and Tai (2021) developed an AI model using 3D depth cameras to monitor pig movements and identify high-risk zones for ASF outbreaks. Similar systems could be adapted for diseases like rabies, providing veterinary services with early alerts based on real-time animal behavior. In countries like the U.S., AI platforms are already transforming veterinary diagnostics. AI-powered diagnostic tools can now analyse radiographs, blood samples, and fecal tests to automatically detect abnormalities. Systems like SignalPET's SignalRAY, Vetology's AI radiology service, and Zoetis' Vetscan Imagyst are already making this possible in veterinary clinics (SignalPET 2025; Vetology 2025; Zoetis 2025). Meanwhile, IDEXX's SediVue Dx Analyzer uses machine learning to interpret urine sediment, streamlining lab workflows (IDEXX 2025). These technologies may seem out of reach; but they offer a

vision of what's possible for Borneo. A local version of these platforms could be trained using local data to support disease detection and treatment planning in government and rural clinics.

FROM WEARABLES TO SMART FARMS: MONITORING ANIMALS IN REAL TIME

Real-time health monitoring is another area where AI and digital technologies is making a difference. In developed countries, wearable sensors and GPS tags allow farmers and vets to track livestock and pets remotely. These devices can detect changes in movement, temperature, or feeding behavior, which helps identify illness before symptoms become severe (Kumar & Jakhar 2022). For Borneo, adopting similar technologies could greatly improve disease response, especially in remote areas where regular checkups are difficult. For instance, RFID ear tags on cows or GPS collars on dogs could alert vets when animals behave abnormally, enabling early treatment and reducing the risk of outbreaks. AI is also helping to automate daily vet tasks like appointment booking, client communications, and even note-taking during consultations (Wallace 2022). While these features are more common in large clinics in developed countries, early pilots in Borneo could help ease administrative workloads and improve veterinary service delivery.

LOOKING AHEAD: BUILDING A SMARTER FUTURE

"We want more stakeholders involved in understanding the dangers posed by animals like dogs that carry the rabies virus..." (DVS Sarawak 2025c), urges Datuk Seri Dr Stephen Rundi Utom. This call for broader engagement reflects the collaborative spirit needed to transform Borneo's veterinary landscape. Borneo is already laying the foundation for smarter animal health systems, supported by strong disease surveillance, committed institutions, and growing interest in digital innovation. But to unlock the full potential of AI and smart technologies, a few key steps are still needed. First, animal health data must be digitised, standardised, and made accessible across agencies. Second, local universities and training centres should invest in building talent pipelines in AI and veterinary informatics. And finally, bridging the digital divide, especially in rural and indigenous communities, remains critical to ensuring no one is left behind in this transformation.

Borneo faces a choice: invest in smart animal health systems now or continue reacting to deadly outbreaks as they emerge. The tools are within reach, the partnerships are forming, and the need has never been clearer. With the right partnerships and investments, we can better protect animal health, public safety and food security—not just today, but for generations to come. What remains is turning possibility into action.

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BORNEO'S PALM BIOMASS: TRANSFORMING WASTE INTO “BLACK GOLD”

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Endowed with the tropical rainforest climate, Malaysia is rich in biomass resources, and Sarawak, in particular, produces the highest amount of palm biomass in the country. Palmae biomass is generated from agriculture, including oil palm, sago, and coconut. These under-utilised palm biomass residues can be transformed into value-added products.

Malaysia's biomass landscape is dominated by palm-oil residues, over half of the national total, spanning 6.49 million t of palm kernel shells (PKS), 260,800 t of empty fruit bunches (EFB), and 159,900 t of palm mesocarp fibre (PMF) (Su et al. 2022). Coconut milk production generates coconut husk fibre and shell, while sago starch extraction leaves behind sago fibre, trunk bark, and pith. When these resource streams leak from the proper management loop, such as being used for open burning or abandoned in the field, of which their unmanaged decay would release pollutants and breed pests and diseases, hence forfeiting their latent value. Circular bio-economy strategies plug these leaks by using technologies such as pyrolysis which convert biomass into biochar, a carbon-rich material that returns carbon and nutrients to the soil. By designing such “closed-loop” pathways, the agricultural waste, instead of being disposal liabilities, can be transformed into circular assets that power rural livelihoods and climate resilience.

Pyrolysis, a process of heating biomass under low oxygen, transforms wastes into valuable biochar, bio-oil and syngas fuels. This approach kills three birds with one stone: (1) reduces waste, (2) creates useful products, and (3) locks away the carbon. Biochar is increasingly being recognised as an ideal material for sustainable land management (Bandh 2022; Dwibedi et al. 2022). When added to the soil, it can improve its fertility, retain the moisture, while sequestering carbon into stable form. Biochar made from well-studied

feedstocks such as coconut shells reliably raises soil pH, enriches nutrient availability, and stimulates plant growth. Malaysia's under-explored residues includes palm mesocarp fibre (PMF), sago trunk bark (STB), and coarse sago fibre (SFC).

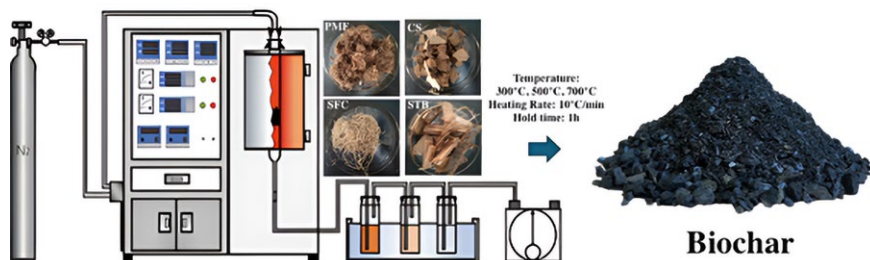
WHY PALMAE WASTE IS A CIRCULAR GOLDMINE?

Palm-Mesocarp Fibre (PMF) that is the leftover pulp from oil extraction, carries the highest ash load among our four feedstocks (≈ 12 wt %)—meaning it is rich in farm-friendly minerals such as K, Ca and Mg (Yeong et al. 2025). Nitrogen sits at a respectable 2.6 wt.%. Moisture is high, so pyrolysis must be tuned, but the payoff is a nutrient-rich char.

Dense, woody, and almost mineral-free, Coconut Shell (CS) carries just ~ 0.5 wt.% ash and negligible nitrogen. Due to its fixed carbon and lignin, the biochar produced has ultra-high porosity and long-term stability. Think of CS as the “carbon backbone” of any biochar blend—ideal for locking up CO_2 and polishing polluted soils, even if it offers little direct fertiliser value. \rightarrow Loops durable carbon back into plantation soils while supporting remediation markets.

Sago Coarse Fibre (SFC) is rich in reactive cellulose and hemicellulose, driving easy devolatilisation yet leaving just ≈ 3 wt.% ash and ≤ 0.5 wt.% N. The result: a clean, low-ash char that can lighten compacted paddy soils and serve as a carrier for compost or microbial inoculants. SFC biochar's high surface area makes it a natural sponge for fertiliser retention.

Sago Trunk Bark (STB) being woodier, clocks in at ≈ 22 wt.% fixed carbon and just ≈ 2 wt.% ash has a balanced chemistry of a mid-range biochar which is stable, moderately nutritive and can both sequester carbon and supply trace minerals to rice paddies. By valorising trunk bark waste, STB biochar keeps the sago value chain circular from plantation to pot.



Picture 1: The process from crop waste to “black gold”.

Table 1: The physicochemical properties of four Bornean palmae biomasses.

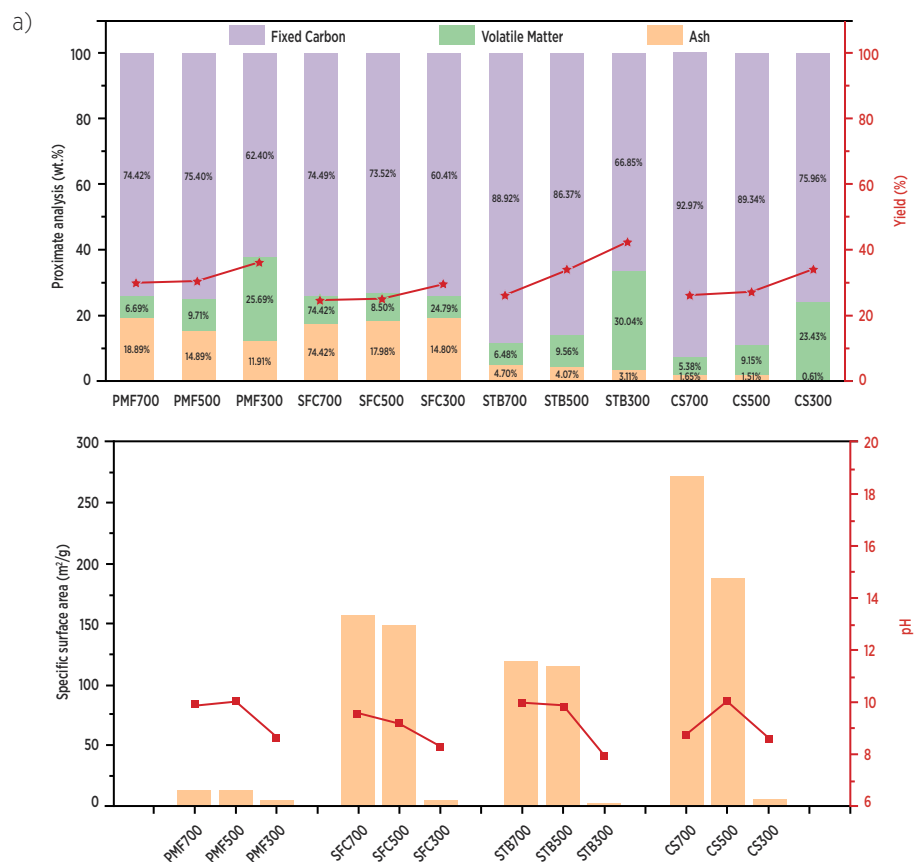
Sample	Ultimate analysis (%)			Proximate analysis (wt.%)			
	C	N	S	Moisture	Ash	Volatile Matter	Fixed Carbon
PMF	40.97	2.59	0.04	20.5	12.2	78.13	21.41
SFC	41.73	0.57	0.09	12.53	3.99	71.56	20.07
STB	41.6	0.47	0.04	11.45	2.42	75.81	22.21
CS	45.48	0.23	0.01	9.73	0.46	77.02	20.27

Note: Proximate analysis was conducted per Chinese National Standard GB/T 28731-2012 using the mass balance method. Totals may exceed 100% due to moisture-free or ash-free reporting bases.

STRIKING THE RIGHT BALANCE IN THE PYROLYSIS CONDITION

Batches of each residue were slow-pyrolysed at 300 °C, 500 °C and 700 °C in our study (Pictures 1 & 2). The biochars are all alkaline (pH 9–10), potentially a tonic for typical acidic tropical soils. The “sweet spot” proved to be 500 °C with a gentle 10 °C min⁻¹ ramp: hot enough to build fixed-carbon, yet cool enough to preserve the mineral ash that plants crave.

PMF carbonised at 500 °C (PMF500) has modest surface area (~ 13 m² g⁻¹), yet good in nutrient and cation-exchange capacity (~ 25 cmol kg⁻¹) making it all-round soil conditioner. CS500, by contrast, is almost pure carbon (C/N ≈ 630) and virtually nutrient-free; ideal for uptake of heavy-metal or hydrocarbon pollution rather than feeding crops. STB500 lagged on surface area and nutrient, hence limiting its usage in agriculture.



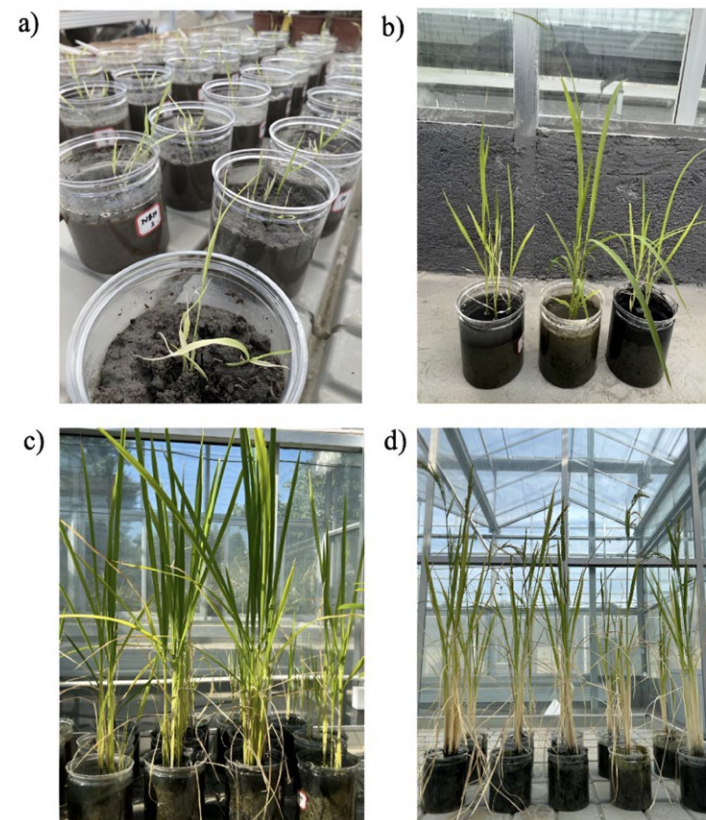
Picture 2: Physicochemical properties of different Palmae biochar at different temperatures. (a) Proximate analysis (wt.%) and yield; (b) Specific surface area and pH.

Our thermogravimetric (TG) and derivative thermogravimetric (DTG) studies showed that the kinetic fits using the Coats–Redfern method reinforce the story: PMF posts the lowest activation energy ($\approx 61 \text{ kJ mol}^{-1}$), followed by CS ($\approx 67 \text{ kJ mol}^{-1}$) and SFC (80–139 kJ mol^{-1}). In plain terms, PMF is likely the more cost-effective biomass to carbonise, good news for Sarawak’s palm-oil mills that have mountain loads of mesocarp fibre.

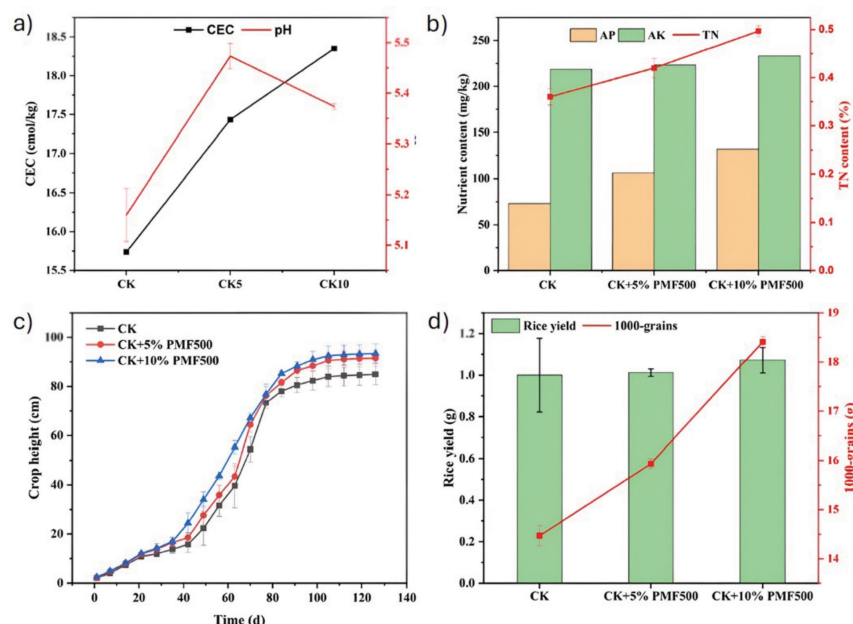
SOIL GAINS AND THE CARBON LEDGER

In pot trials on acid paddy soil, palm mesocarp fibre (PMF) biochar produced at 500 °C (PMF500) emerged as the all-round performer. When incorporated at 10 wt.% alongside standard fertiliser, PMF500 lifted (1) soil pH and cation-exchange capacity (CEC), (2) plant height, tiller number, and 1 000-grain weight, ultimately translating into the highest

rice yield of the series (Pictures 3 and 4). Biochar’s climate dividend was quantified with the recalcitrance index R_{50} , which benchmarks oxidation resistance against pure graphite. PMF500 returned $R_{50} = 0.53$, implying that $\approx 51\%$ of its carbon will persist in soil for centuries. Converting Malaysia’s annual PMF stream at this setting could sequester $\approx 5.4 \text{ Mt CO}_2 \text{ year}^{-1}$; even a 10 % uptake locks away $\approx 0.43 \text{ Mt CO}_2$.



Picture 3: Growth stages of paddy rice in pot trial: (a) seedling stage, (b) tillering and vegetative growth, (c) reproductive growth and grain formation, and (d) maturation and harvesting.



Picture 4: (a) CEC contents and pH; (b) TN, AP, and AK contents; (c) crop height of different treatments; (d) rice yield, and 1000 grains of various treatments.

From a conservative uptake scenario, i.e. carbonising just 10% of Malaysia’s mesocarp-fibre stream, would sequester roughly 0.43 Mt CO₂ each year (Table 1). Even this modest diversion delivers a regionally significant climate benefit, while the resulting biochar simultaneously enhances soil chemistry and structure. Such twin gains (carbon locked below-ground, productivity lifted above) sit at the heart of emerging “carbon-farming” initiatives.

Table 1: Summary of the theoretical potential for PMF500 biochar production and long-term carbon storage across different utilisation scenarios (A, B, and C).

	Scenario A	Scenario B	Scenario C
Biomass Availability (Mt/year)	7.10	3.55	0.71
Pyrolysis Yield (%wt.)	30.45	30.45	30.45
Biochar Yield (Mt/year)	2.16	1.08	0.22
Biochar Carbon (Mt/year)	1.47	0.74	0.15
CO _{2eq} of Biochar Carbon (Mt/year)	5.39	2.7	0.54
C Remaining Long-Term (Mt/year)	1.18	0.59	0.12
CO _{2eq} of C Stored Long-Term (Mt/year)	4.33	2.17	0.43

*Note: Scenario A assumes 100% of residues are utilised, Scenario B represents 50% of residues availability, while Scenario C adopts a 10% availability of residues.

WASTE TO WEALTH FOR SARAWAK’S FUTURE

What was once seen as “agricultural waste” – palm fibers, sago bark, sago fibers, coconut shells – is now proving to be a resource for sustainability. Slow-pyrolysing these Bornean palmae residues into biochar delivers a three-way return: (1) it diverts biomass from open burning or landfill, (2) enriches the acidic tropical soils that constrain yields, and (3) immobilises a sizeable share of carbon that would otherwise re-enter the atmosphere. Mesocarp fibre produces a nutrient-laden, moderately recalcitrant biochar that lifted rice growth in pot trials by improving pH, cation-exchange capacity and water retention. Sago residues, long a disposal headache for the starch industry, can be carbonised into a lightweight soil conditioner that loosens texture and curbs moisture loss, while coconut shell, already prized for high-grade char, excels as a stable carbon store and contaminant sorbent.

Widespread adoption of such biochar could weave climate-smart agriculture into existing plantation and paddy systems, boosting crop productivity even as long-lived carbon stocks accumulate in the soil—directly supporting Malaysia’s emissions-reduction commitments. This approach exemplifies the “waste-to-wealth” concept – turning low-value biomass refuse into a product that supports both economic agriculture and environmental well-being. Institute of Urban Environment of the Chinese Academy of Sciences, Swinburne University of Technology Sarawak Campus and NGOs such as Alliance of Bioeconomy Community Development based in Sabah, all support the idea of managing palm wastes in such a way that would feed the soil and temper climate change in one single stroke. “Borneo’s black gold” (biochar) can potentially move from experimental plots to everyday farm practice across the region, enriching the soil for generations to come.

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TINY BEES, BIG CLUES

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According to the World Wildlife Fund (WWF) [1], Borneo ranks among the most biologically diverse regions in the world, with thousands of unique plant and animal species found nowhere else on Earth. With its lush forests, rich plant life, and centuries of indigenous knowledge, the island holds natural treasures of both ecological and economic value. One such treasure is stingless bee honey, locally known as *madu kelulut*. Produced by small tropical bees native to regions such as Sarawak, Sabah, Brunei and Kalimantan, stingless bee honey is valued not only for the ease of hive management, thanks to the bees' lack of a functional sting, but also for its unique characteristics shaped by Borneo's rich biodiversity.

At least 33 species of stingless bees from a variety of genera have been recorded in Borneo, making it one of the richest regions for stingless bee biodiversity in Southeast Asia [2][3]. These species include both widely domesticated types like *Heterotrigona itama* (Picture 1) and *Geniotrigona thoracica*, and lesser-known wild species, some of which are likely endemic or still under-researched. As Borneo faces increasing environmental and socio-economic challenges, this unique honey is gaining recognition not only as a traditional food but also as a potential pathway to sustainable innovation.



Picture 1: Natural arrangement of honey pots in a colony of the stingless bee, *Heterotrigona itama*.

Stingless bee honey (Picture 2) differs from the more common honeybee honey in several ways. It is more liquid, tangier in taste, and rich in bioactive compounds such as phenolics and flavonoids, which are known for their antioxidant and antimicrobial properties. Long used in traditional medicine, this honey is now attracting scientific attention for its health benefits and commercial potentials.



Picture 2: Natural colour diversity of stingless bee honey, ranging from light to dark brown, influenced by floral and environmental sources.

To better understand and promote the unique qualities of this honey, researchers are applying accessible technologies that blend traditional ecological knowledge with modern science. Techniques such as pollen analysis and infrared spectroscopy have proven especially useful for identifying the floral origins of stingless bee honey and verifying its authenticity [4]. These tools not only support traceability and quality control but also help connect honey to Borneo's rich biodiversity. In fact, some of the plant species identified in honey, such as those from the *genera Melastoma*, are found only in Borneo, making them strong markers of geographic origin [5]. This kind of evidence is essential for local producers who want to add credibility and value to their products in both domestic and global markets. In future studies, DNA barcoding could offer additional advantages in terms of speed, accuracy, and the ability to identify a wider range of organisms beyond pollen, further enhancing the precision of honey authentication and biodiversity mapping.

Other studies have shown how data-driven approaches can further support the development of stingless bee honey as a value-added product. For instance, by using statistical tools like Principal Component Analysis (PCA), researchers have begun classifying honey types based on their chemical properties to suggest whether they are best suited for

daily consumption, therapeutic use, or medicinal applications [6]. While early findings are promising, further research is needed to expand sample sizes and validate the patterns identified. Still, the potential is clear. These simple but powerful techniques can guide honey production, branding, and quality control, especially for rural communities.

The PCA analysis revealed that one honey sample from a Sarawak-based stingless bee producer stood out as the most promising for clinical or medicinal use [6]. This honey had high free acidity and powerful antioxidant activity, both of which are known to help fight bacteria and protect against cell damage. It also contained the highest level of total phenolic compounds among the samples analysed. These plant-based compounds are known to support immune function and reduce inflammation, making this local honey a strong candidate for use in natural healing and therapeutic products.

The same PCA-based approach also helps in identifying which honeys are better suited for dietary use based on desirable flavour and texture profiles. Some stingless bee honeys with higher sugar content and lower moisture levels may appeal more to consumers who prefer a sweeter taste and thicker consistency. This kind of data-guided matching, choosing the right honey for the right purpose allows producers, retailers, and consumers to make more informed choices and explore honey's full potential in both health and food applications. Building on this, future research could expand the use of data-driven methods to better classify stingless bee honeys according to their chemical and functional properties. Exploring a wider range of analytical approaches may enhance the accuracy of such classifications, supporting more targeted product development and strengthening the role of honey in both local economies and health-related markets.

Another study found that Sarawak stingless bee honey has both antibacterial and anti-biofilm properties against *Pseudomonas aeruginosa*, a drug-resistant pathogen, indicating its potential as a natural alternative for managing microbial infections [7]. Other studies have shown that the bioactive compounds in honey can vary depending on the bees' environment, and that proper processing such as avoiding high heat is essential to preserve its beneficial properties [8]. Technologies like near-infrared spectroscopy now offer fast, non-destructive quality checks, and a practical tool for enhancing quality control and adding value at the production level [9]. Together, these findings reinforce that Borneo's stingless bee honey is more than just a traditional product. It is an asset with ecological, economic, and scientific value.

While more research is still needed, particularly larger, region-wide studies that explore antimicrobial activity, nutritional profiles, and environmental impacts, the current findings are already compelling. Stingless bee honey from Borneo presents a rare convergence of ecological richness, health potential, and economic promise. It demonstrates how local traditions, ecological knowledge, and accessible scientific tools can work together to elevate a native resource into a catalyst for innovation.

Supporting stingless beekeeping contributes not only to rural and indigenous livelihoods, but also to the conservation of native forests and the pollination of diverse

plant life. This aligns directly with Sarawak's Post COVID-19 Development Strategy 2030 [10], which emphasise biodiversity protection, sustainable livelihoods, and inclusive growth through eco-innovation. By harnessing both traditional practices and modern science, communities are creating sustainable pathways rooted in biodiversity and resilience.

As researchers continue to decode the floral origins and bioactive properties of this honey, it becomes clear that stingless bees are doing more than making honey. They are leaving behind a trail of insights. Stingless bees leave clues in every drop, and it is up to us to read them.

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THE PICK-UP AND DROP-OFF (PUDO) INDEX SYSTEM

ASSESSING THE READINESS OF A FACILITY TO DEPLOY PUDO SERVICES

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EXECUTIVE SUMMARY

The expansion of e-commerce and digital platforms has transformed consumer behaviour, making last-mile delivery a critical component of the logistics ecosystem. However, rural and remote areas often lack the infrastructure and systems needed to support efficient delivery services, especially in Sarawak, with its diverse and dispersed geographical locations, characterised by rugged terrain, dense rainforests, and numerous rivers. To address this challenge, the Pick-up and Drop-off (PUDO) Index System was developed as a practical tool to assess the readiness and suitability of a facility to host PUDO services. The system uses clear criteria such as accessibility, internet access, local support, and available infrastructure to measure readiness. Each factor is weighted differently based on how important it is, using expert input through a method called the Best-Worst Method. These are built into a user-friendly digital platform that calculates and compares scores instantly. Tested at 29 Digital Economic Centres (PEDi) centers, the system proved effective in identifying locations with high potential. It can also be used in schools, retail outlets, or government service points. In conclusion, the PUDO Index System is a simple and smart way to help improve last-mile delivery by guiding better site selection in underserved areas.

CONCEPTUAL FRAMEWORK AND RATIONALE

Last-mile delivery is often the most expensive and operationally complex segment of the logistics chain. In remote regions, this challenge is compounded by poor infrastructure, limited digital access, and fragmented delivery networks. Traditional methods of selecting PUDO sites are often ad hoc, lacking standard assessment criteria. The PUDO

Index System was conceptualised to fill this gap by offering a structured, data-driven approach to evaluate a facility's readiness based on multiple dimensions, including accessibility, infrastructure, digital connectivity, and community engagement, to ensure the sustainability of the PUDO facilities and services, while optimising the facilities and services for local economic development.

OBJECTIVE

The primary goal of the PUDO Index System is to provide a scalable, replicable tool for evaluating the suitability of facilities (eg. community centers, retail outlets, or educational institutions, etc.) for hosting PUDO services. By standardising assessment criteria, the system enables service providers, policymakers, and community planners to make strategic decisions that support inclusive and efficient delivery networks.

METHODOLOGY

Instrument Development

The instrument was designed through a multi-phase process:

- i. Indicator identification based on field observations, interviews with courier service and PUDO operators, and literature review.
- ii. Instrument validation and refinement through expert input.
- iii. Pilot testing conducted at 5 PEDI locations in Kuching, Sarawak, Malaysia

The questionnaire includes both quantitative and qualitative indicators related to logistics feasibility, user demand, facility capability, and community readiness.

Development of the Index

The PUDO Index was created using a method called the Best-Worst Method. In this process, a group of experts chooses the most important and least important factors from a list of criteria. This helps identify which factors matter most when evaluating PUDO (Pick-Up and Drop-Off) points. The experts fill out a questionnaire where they rank the importance of each criterion and compare the most important ones with others, as well as compare less important ones. This gathers their opinions on what matters most.

Next, the researcher uses a technique called Bayesian analysis to calculate the importance, or weight, of each criterion based on the experts' answers. This method, called Bayesian BWM, combines the opinions of all experts to get a clear understanding of which factors are most important. It provides more accurate and reliable results, helping to make better decisions about PUDO locations and evaluations.

System Development

To implement the index, a digital platform was created that applies the predetermined weights in the calculation formula to produce the index score. The platform is user-friendly and can be accessed via laptops, tablets, or smartphones. Users can easily input data, and the platform instantly calculates the PUDO Readiness Index Score. Key features of the system include:

- A mobile-friendly assessment form for easy data entry
- A map showing the locations of evaluated facilities with geo-tagging
- Real-time calculation of the index score
- Options to sort results and export data for further analysis

System User Testing

User testing is conducted concurrently with the actual data collection at 29 PEDI locations. The PUDO@PEDI pilot test successfully demonstrated the system's effectiveness in rapidly identifying high-potential PUDO locations, providing objective comparisons across facilities, and empowering local operators to understand and enhance their service readiness. Facilities equipped with strong digital infrastructure, community support, and strategic locations consistently outperformed others, validating the relevance of the index indicators. Importantly, while initially focused on public digital economy centers, the PUDO Index System's applications extend beyond PEDI, such as urban micro-hubs, rural cooperatives, educational institutions, retail sites, and government service points. This versatility can significantly enhance delivery access in underserved areas, reduce logistical costs, support digital and economic inclusion, and facilitate data-driven infrastructure planning, making it a powerful tool for broad-based development initiatives.

SYSTEM ARCHITECTURE AND FEATURES

The system includes homepage, assessment form, facility location map, facility info lists, and index result viewer.

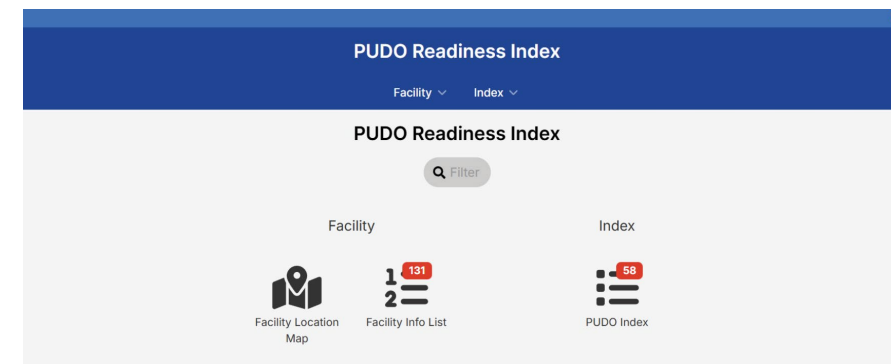


Figure 1: Homepage: User login and navigation hub.

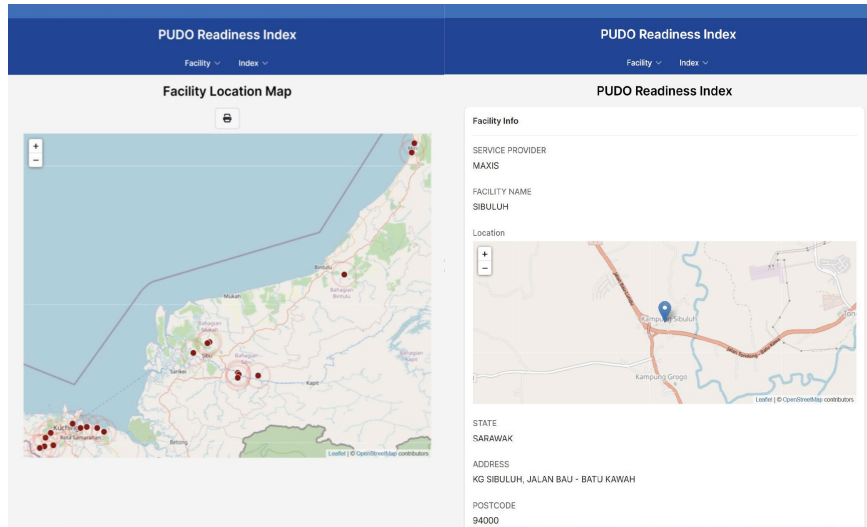


Figure 2: Facility location map: Geo-visualisation of assessed and unassessed sites.

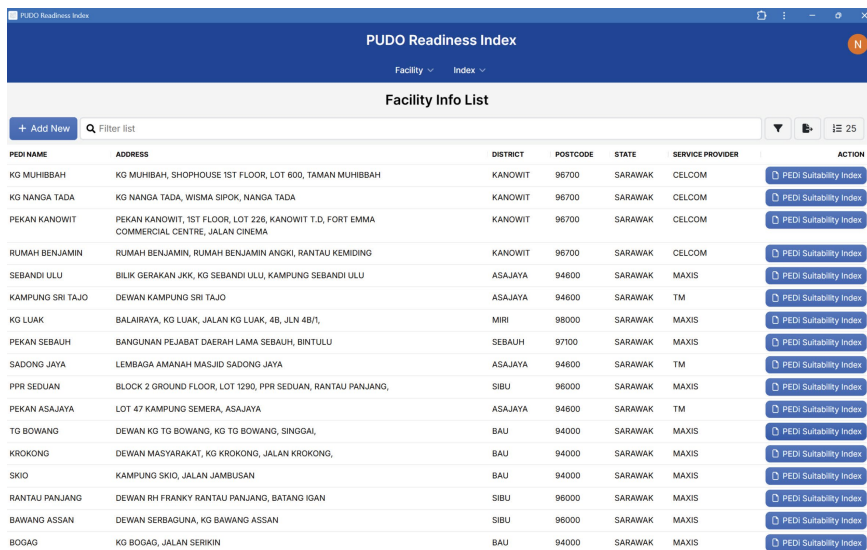


Figure 3: Facility Info List: Database of registered centers and attributes.

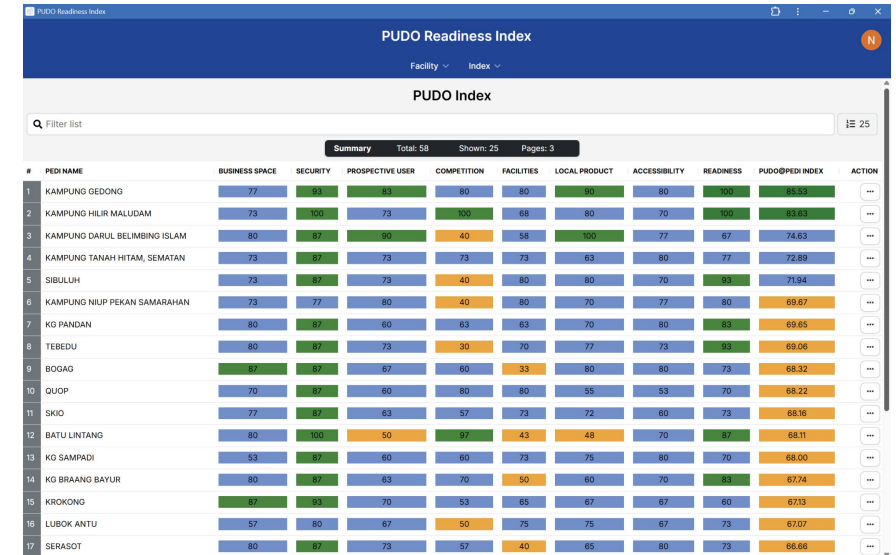


Figure 4: Index Result Viewer: Ranked list based on index scores for easy decision-making. The results were sorted automatically from the highest to lowest.

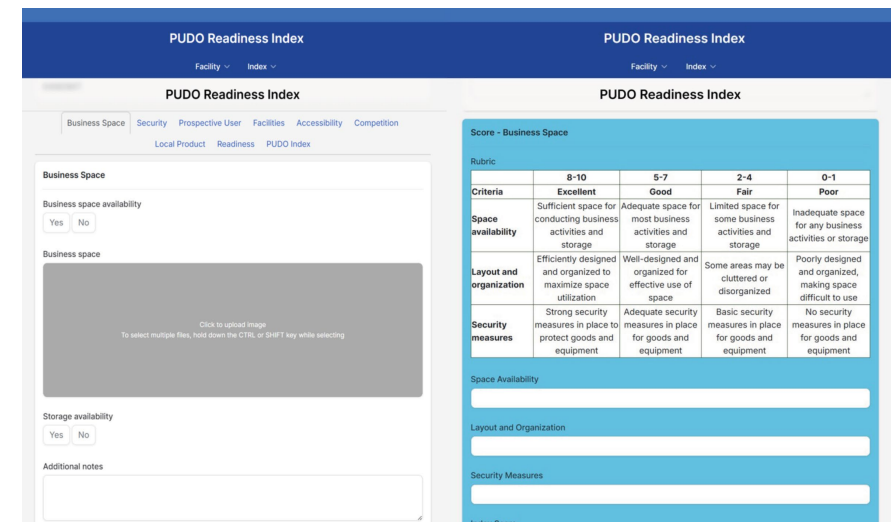


Figure 5: User Interface.

FUNDING AND IP REGISTRATION

This project was funded by the Malaysian Communications and Multimedia Commission (MCMC) to support improved delivery access in underserved areas. As a result, two intellectual properties, the index framework and digital system were successfully registered to protect and formalise the innovation.

SDG ALIGNMENT

The PUDO Index System is related to the following Sustainable Development Goals (SDGs):

1. SDG 9 – Industry, Innovation and Infrastructure
2. SDG 11 – Sustainable Cities and Communities
3. SDG 8 – Decent Work and Economic Growth
4. SDG 10 – Reduced Inequalities
5. SDG 17 – Partnerships for the Goals

CONCLUSION

The PUDO Index System provides a replicable, scalable, and flexible approach to evaluate the readiness of any facility to serve as a Pick-Up and Drop-Off point. It is a powerful tool that aligns with global goals to strengthen rural logistics and promote equitable access to digital services. The successful implementation of the PUDO@PEDi pilot confirms the system's potential to transform last-mile delivery strategies in Malaysia and beyond.

DRONE TECHNOLOGY AND DESIGN PROCESS

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INTRODUCTION

Drone is an aircraft that can fly, control and navigate without aircrew on-board. This type of aircraft is commonly known as Unmanned Aerial Vehicle (UAV) or Unmanned Aircraft System (UAS) equipped with special equipment to meet their mission requirement.

The potential of drone as a form of air mobility is very promising, and it's evolving quickly as technology, regulation, and public acceptance progress. For future Sarawak, drone is potential to become Urban Air Mobility for short-range passengers travel within cities or Point-to-Point Services ideal for connection airports to city centres or between key urban hubs. Drone is also suitable for cargo and logistics for supply chain efficiency. Drone services lead to cost saving, green mobility and job creation. Autonomous flight, advanced air traffic management and drone design will promote technological potential in Sarawak.

TYPICAL DRONE CATEGORY AND DESIGN REQUIREMENTS

The general configuration of the drone can be divided into three types: fixed-wing, rotor-craft or combination of these two types. General public, particularly in Malaysia is widely exposed to a very small, lightweight drone. Most of them fall into micro drone UAV (MUAV) category, with limited operation, for personal use, flying within line of sight for taking photos, videos and recreational purposes. In contrary, there are drones with a size of general aviation aircraft, close to a size of a Boeing 737 with a flying range of thousand kilometres, and can fly more than 24 hours endurance, cruising at more than 20,000 feet and capable to fly day and night. Drone categories are grouped by its size, weight, range, endurance and cruising altitudes as shown in Figure 1.

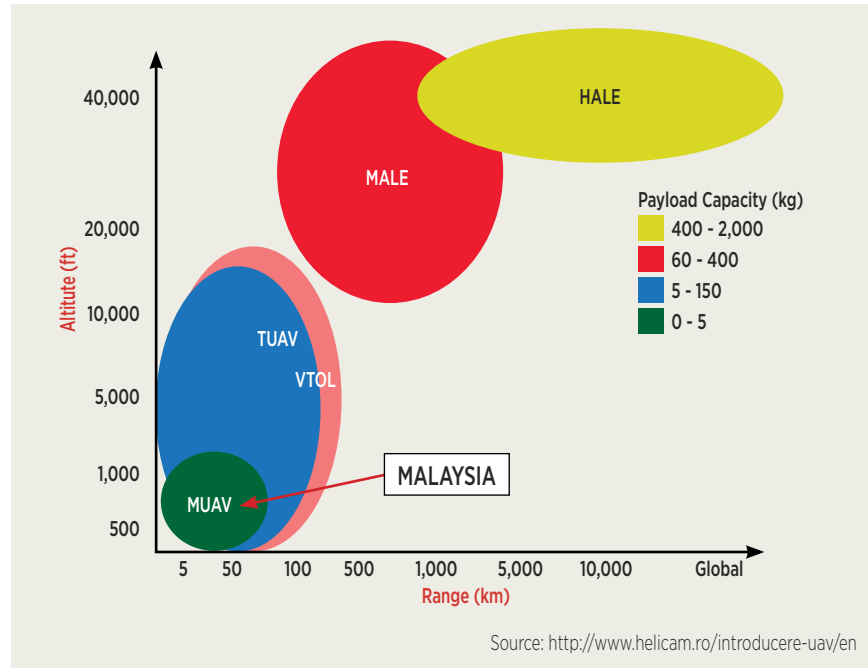


Figure 1: Drone category based on flying altitude, range and payload capacity.

For MUAV (Micro UAV) category drone, maximum take-off weight of less than 5 kg can be purchased off-the-shelf with complete ready-to-fly (RTF) drone kits. For a medium and bigger size of drone with high performance and capability, carrying expensive of equipment on-board such as MALE (Medium Altitude Long Endurance) drone and HALE (High Altitude Long Endurance) drone category, the “trial-and-error” design approach is not feasible. This is due high risks of crashing, uneconomical and uncontrollable flight. For that, full understanding of aircraft aerodynamics, flight stability and control, structures and materials, propulsion systems, avionics, system integration are prerequisite to a success of drone design development.

DRONE DESIGN PROCESS

For a large drone more than 20kg of weight, the drone has to be designed systematically. The design process is not just to ensure the drone can fly safely to meet the mission requirements, but it is very important for design process documentation in which will be required for airworthiness and certification process.

Accurate information on aerodynamics, stability and control are very crucial steps to be taken before we can design an autopilot system to fulfil its mission requirements

autonomously. Flight control and autopilot system are designed to meet a specific airframe configuration (i.e., shapes, geometry and dimensions), stability and performances. The stability of the drone has to be improved with accurate and precise flying response. This will ensure that the autopilot can follow and maintain the waypoints precisely. The best method to get accurate aerodynamics data, stability data and control parameters are from experimental methods such as wind tunnel and flight testing.

Most of the off-the-shelf drone has embedded autopilot, normally has limited capability and performances. Any modification to the platform configurations, for example altering the shape and weight, may change location of the centre of gravity, moment of inertia, aerodynamic and dynamic responses of the drone. This will upset the original flight control system of the embedded controller and needs to be re-tuned or re-designed. Most of the time the user will always face limitations and constraints to modify the original airframe, configuration and shape. So, the performance and capability of the drone is limited and difficult to predict which can lead to failure and crashed flight. For that, a systematic design process, proper fabrication methods and flight-testing activities have to be conducted professionally.

DRONE PROJECT MANAGEMENT

Figure 2 shows a typical aircraft design process including drone. Typical design process milestones from feasibility studies to prototyping flight testing will be conducted to propose a suitable configuration of the drone to meet the end-user’s requirements, scope of supply, operations and demand. At the same time, the proposed designed must comply with airworthiness requirements.

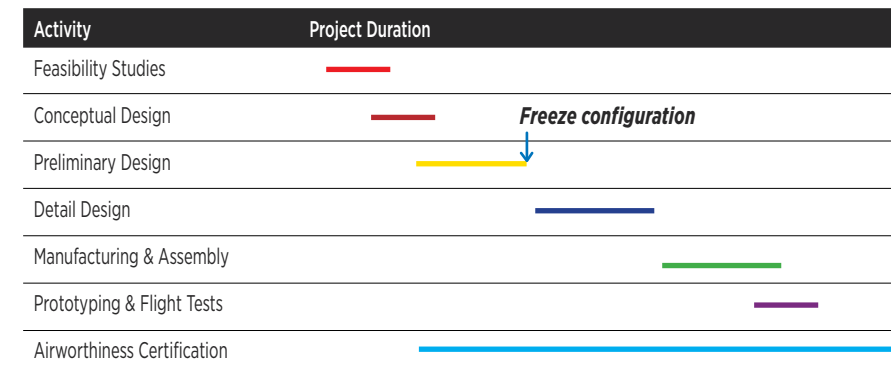


Figure 2: Aerospace vehicle design process applicable to drone design

Flight control and autopilot design is a very important system of the drone to ensure the fulfilment of flight missions, precise waypoints and navigation control. Figure 3 shows how the overall implemented in the conceptual, preliminary design phase of the drone including the flight control system design process.

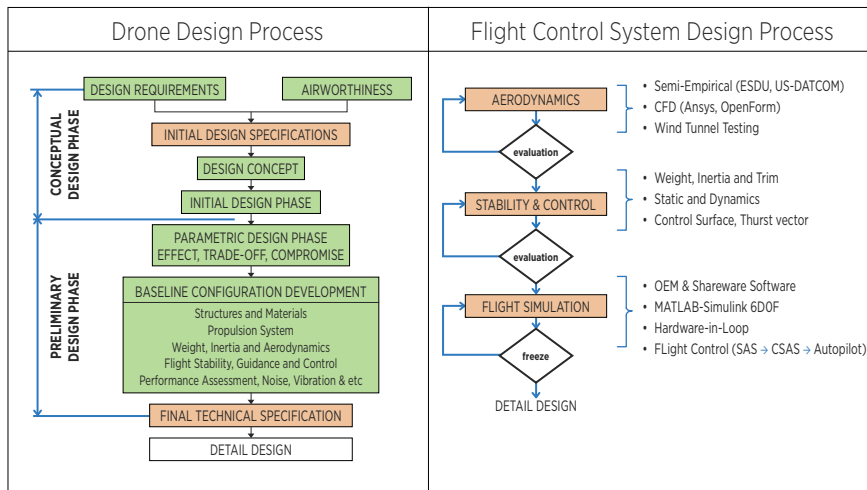


Figure 3: Drone design process related to flight control system design.

This flowchart helps to design a good response and precise tracking of drone manoeuvrability to follow specified waypoints. In the initial design stage, the drone aerodynamic, stability and control can be calculated using aircraft design guideline and simulation using computational fluid dynamics (CFD) and MATLAB. Later, the evaluation of the aerodynamic, stability and control of the drone will be confirmed by experimental methods.

In the stability and control analysis, the drone aircraft should be able to be trimmed under normal flight conditions for all flight cases within the designed enveloped (i.e., at various speeds, altitudes and 'g' loads). The inherent stability for all flight cases must be well analysed because the flight control strategy has to be designed based on the drone stability initial stability (i.e., without any flight control system installed). Next, a simple feedback control system is design to achieve a good drone transient response. Once the transient response of the drone has been improved using simple feedback control system, the advanced flight control system will be designed to meet the specified flight path and target point. Finally, the autopilot system is designed to ensure the drone is able to maintain its position and waypoints accurately though out the flight specified flight path. A stable drone will return to its original waypoints and flight path if it is being disturbed by turbulence or wind gust.

SYSTEM INTEGRATION AND TESTING

Overall design process for system integration and testing is shown in Figure 4. There are two major phases (circled by the dotted lines), which is the design process and flight testing. The intersection between those two boxes is the activity for parameter tuning which involves software-in-the-loop (SIL) and hardware-in-the-loop (HIL) simulation activity. It is a process where the aerodynamics, stability and control of the airframe is simulated with software and hardware integration.

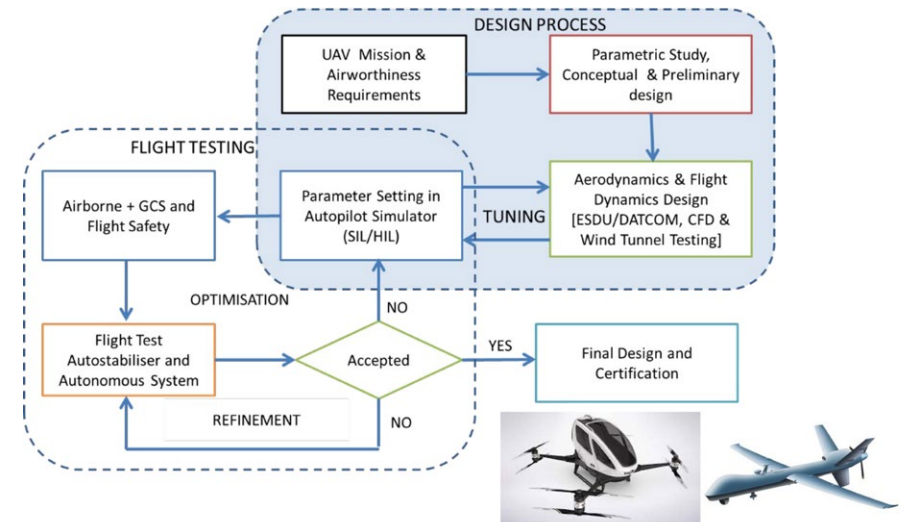


Figure 4: System Integration, software & hardware in-the-loop (SIL/HIL) and flight testing.

In flight testing, the auto stabiliser performance is tested and evaluated. The other system such as Airborne System, Ground Control System (GCS) and Flight Safety System that are being integrated in the drone system must also be tested together during the flight testing. The final outcome of the design process plus the SIL/HIL testing is a well-designed drone prototype. This design process can be used as a guideline especially for medium range to high-altitude long-range drone and for tactical and combat drone. In addition, a well documentation of design process, analysis and testing is useful for drone certification. Furthermore, it can be used for future drone design references and data-bases

DESIGN OPTIMISATION AND DRONE R&D ECOSYSTEM AND SUPPLY-CHAIN.

The systematic aircraft design process helps to optimise drone design configurations to meet end-users' requirements including training, operation, service, maintenance and certification. Well organised and strategic planning of the drone operational procedure will result in cost saving and safer operation which also include service and maintenance. Systematic documentation control and data-base will help the drone certification process and also to support future drone design activities. Local Regulation and Airworthiness authority such as CAAM and DGTA has to assist local drone design and certification activities. Hence, in house drone design development with system-integration and multi-disciplinary approach will increase local contents and capacity building with sustainable UAS research and development ecosystem.

Based on local resources available (expertise and facilities), Sarawak state and Malaysia has capability to design and develop drone in-house. It is very important to strengthen local resources and capabilities with sustainable financial system and R&D ecosystem. Local contents can be increased if we can integrate those area of expertise in designing, manufacturing, testing, operation and maintenance (shown in Figure 5) of our indigenous unmanned aircraft.

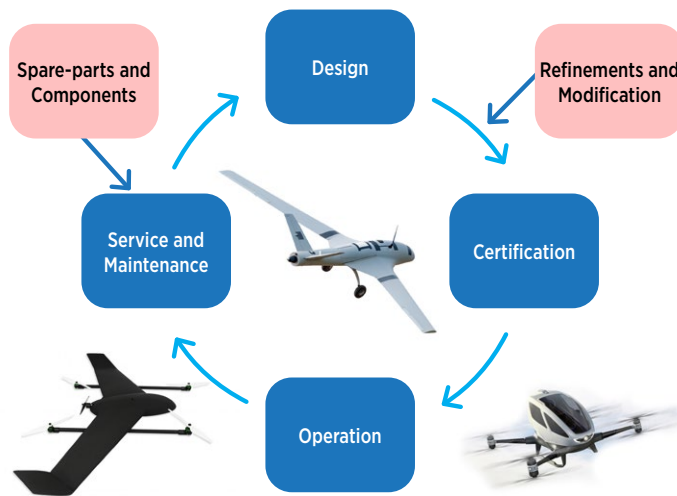


Figure 5: Design, manufacturing, certification, operation and maintenance life-cycle of drone.

Drones have potential to transport air mobility much like automobiles transformed land transport in the 20th century. They could create a new ecosystem of On-demand, sustainable, and accessible air transport for both goods and people, particularly in urban areas and unserved regions. The next 5-15 years will be crucial in proving large-scale feasibility, safety, and public trust.

ONLINE LEARNING SATISFACTION: A LONGITUDINAL PERSPECTIVE

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ONLINE LEARNING

March 2020 is a date that gives a very significant impact to the whole world. This pandemic has brought many changes across various industries and about how people live, socialise, and run daily activities. The spread of COVID-19 has changed the landscape of the entire world, from the decay in industrial production to the closure of educational institutions around the globe. Stakeholders and management of higher learning institutions (HEIs) have no other option but to make use of internet technology, thus online learning for the continuation of teaching and learning. Online learning is used to refer to web-based training, e-learning, distributed learning, Internet-based learning, web-based instruction, cyber learning, virtual learning, or net-based learning. It embraces a wide set of technology applications and learning processes including, computer-based learning, web-based learning, virtual classrooms, and digital collaborations. It must be noted that teaching and learning has shift from the classroom (face-to face) to the online mode. Online learning supports access, equality, skills development, innovation, and sustainability, aligning directly with United Nations Sustainable Development Goals (SDGs)—especially SDG 4 (Quality Education). It's also spreading benefits across social, economic, and environmental goals. Meanwhile, higher learning institutions (HEIs) is required to engage with technology, to enable effective online learning, hence the learning environments would not be disrupted. HEIs have become attentive in how to best deliver course content online, engage learners and conduct assessments. Understanding how students feel and respond to online learning—especially when studied over a longer period—gives HEIs valuable insights. These insights can help them improve and adjust online learning to better match students' needs and expectations. Listening to students' perspectives is important, even though adapting online learning to meet those needs can be challenging.

Evolution of Online Learning

Era	Period	Key Milestone & Technologies	Impact / Characteristics
Early Foundations	1960s-1980s	<ul style="list-style-type: none"> PLATO (1960): First computer-assisted instruction system Email and file sharing emerge 	<ul style="list-style-type: none"> Foundations of e-learning established Mainly text-based and institutional (used by universities and military) Limited access
Internet Emergence	1990s	<ul style="list-style-type: none"> World Wide Web (1991) First online courses (e.g., CALCampus) Learning Management Systems (LMS) like Blackboard (1997) 	<ul style="list-style-type: none"> E-learning becomes more accessible Rise of asynchronous learning Online programs in higher education begin
Web 2.0 & LMS Growth	2000s	<ul style="list-style-type: none"> Moodle (2002) Widespread LMS adoption YouTube (2005) used for education SCORM standard 	<ul style="list-style-type: none"> Interactive content and collaboration tools Increase in blended learning Institutions invest in digital infrastructure
MOOCs & Mobile Learning	2010s	<ul style="list-style-type: none"> Launch of MOOCs (Coursera, edX, Udacity - 2012) Mobile learning apps Flipped 	<ul style="list-style-type: none"> Massive global access to quality education Flexibility in learning Peer learning and forums become common
Pandemic Acceleration	2020-2021 (COVID-19)	<ul style="list-style-type: none"> Rapid shift to online platforms (Zoom, Google Classroom, MS Teams) Surge in EdTech tools 	<ul style="list-style-type: none"> Universal remote learning adoption Challenges in digital divide & engagement Rise of synchronous and hybrid models
Post-Pandemic Innovation	2022-Present	<ul style="list-style-type: none"> AI in education (e.g., ChatGPT, adaptive learning) Immersive tech (AR/VR) Microlearning & lifelong learning platforms 	<ul style="list-style-type: none"> Personalised, data-driven learning Focus on skills-based learning Increased accessibility & global collaboration

Table 1: The evolution of online learning.

ONLINE LEARNING AND SATISFACTION

When students are motivated, they can manage their learning better and are more likely to succeed. In online learning, motivation plays a big role. Things like active participation, feedback from lecturers, and meaningful engagement all help students stay motivated. Motivated and engaged students usually feel more satisfied with their learning, which improves their overall experience.

A well-structured online course is important. Courses that are too rigid can feel limiting, while flexible ones allow students to learn in ways that fit their needs. Good online courses also build a “community of learning,” where students interact with their peers, lecturers, and course materials in meaningful ways. This not only makes learning more satisfying but also encourages deeper understanding and personal growth.

Even though students are at the centre of online learning, lecturers remain vital. They guide discussions, give feedback, and make sure students have access to the best resources. In an online setting, lecturers act more like facilitators than traditional instructors. Their performance—such as how quickly they respond, how available they

are, and how passionate they are—strongly affects how satisfied students feel. Prompt feedback is especially important, as students find it more useful and motivating than delayed responses. Passionate lecturers are more dedicated to their students’ growth and are focused on improving their knowledge and learning experience (Olson, 2003), therefore positively related to students’ satisfaction (Basuony et al., 2021). Passionate lecturers inspire students, boost their confidence, and create a better learning atmosphere.

Learning is not just about absorbing knowledge—it’s also about sharing ideas and working with others. Interactions with peers allow students to exchange thoughts and support one another, which improves learning outcomes and satisfaction. Studies show that students who actively interact with their peers are more motivated and more satisfied with online learning.

The same goes for interactions with lecturers. Whether through live sessions, emails, discussion boards, or feedback on assignments, communication between lecturers and students is essential. Supportive lecturers who listen, encourage participation, and create a respectful environment help students feel more engaged and more satisfied. Good interaction reduces the sense of “distance” in online learning and makes the experience more positive overall. Interaction with other students and students’ satisfaction in China (She et al. 2021), Nigerian (Adewale & Tahir, 2022) explained that students who interact with other students during the teaching and learning process tend to be more satisfied.



LONGITUDINAL DESIGN

A longitudinal design was used, (February, September Semester from 2021/2022 to 2022/2023), work-in-progress study, and evaluated students’ perceptions towards the online learning from HEIs in Sarawak.

SATISFACTION WITH ONLINE LEARNING OVER TIME

Lecturers are a cornerstone of university online education, whereby they are responsible for the majority of the categories and standards in order to maintain quality and students' satisfaction. They are also responsible to maintain the quality of course technology, course content and learner support. Re-educating lecturers to continuously improve their skills and knowledge so that they can perform better as course designers, discussion/technology facilitators, and motivators is paramount. Online mode of higher education is growing tremendously therefore having a strong connection of students and lecturers will help to plan out effective strategies for embarking online learning. There is much that is positive about the online learning selections and that it can assist with a continuity of new and innovative learning development in the formidable knowledge management processes of mass higher education. But the challenges and changes are demanding and remain unpredictable, making the management and resourcing of higher education as difficult as it has ever been.

ACKNOWLEDGEMENTS

We gratefully thank the University of Technology Sarawak.

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KENAF SEED SOFT TOFU: TURNING SARAWAK'S NEW CROP INTO FUTURE FOOD

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SARAWAK'S NEXT GREEN GOLD

Sarawak is entering a new chapter in agriculture. Alongside pepper, oil palm, and rice, a promising newcomer is finding its place in the state's farmlands: kenaf (*Hibiscus cannabinus*). Long valued for its strong fibres, kenaf is now drawing attention as a sustainable, versatile crop with uses that reach far beyond its original purpose.

Recent developments in Bintulu signal the seriousness of this move. In Ulu Sebauh, 2,000 hectares have been allocated for kenaf cultivation under a partnership between the National Kenaf and Tobacco Board (LKTN) and the Ministry of Food Industry, Commodities and Regional Development (MFICORD). According to Deputy Prime Minister Datuk Seri Fadillah Yusof, the focus will not stop at cultivation but will extend to downstream industries, where the real economic value lies.

"I hope this effort does not stop at the planting stage only but continues to the direction of the downstream industry." – Datuk Seri Fadillah Yusof (Borneo Post, 2023).

Meanwhile, in Ulu Kelabat, MFICORD has launched a pilot project for kenaf cultivation and processing. Figure 1 shows the ribbon-cutting ceremony marking the opening of the kenaf project site, attended by key officials including Thaddeus Ling Allu, who emphasised that this initiative could generate significant income for local communities, provided that sustainable land use and clear land ownership are maintained.



Figure 1: Ling (third left) and other dignitaries mark the opening of the kenaf project site in Ulu Kelabat with a ribbon-cutting ceremony. - Photo by Ambrose Rirang (Conny Banji, Borneo Post, Sep 2023).

FROM FIBRE TO FOOD INNOVATION

Globally, kenaf has been used for making industrial building materials, absorbents, paper, and textiles. But at University of Technology Sarawak (UTS), researchers have taken a bold step by transforming kenaf seeds into a high-protein, plant-based food.

The result is kenaf seed soft tofu, a smooth, nutritious tofu alternative made entirely from kenaf seeds. Unlike soy-based tofu, kenaf seed tofu offers a new source of plant protein, essential fatty acids, and bioactive compounds, catering to the growing demand for functional foods and sustainable diets.

HOW KENAF SEED SOFT TOFU IS MADE

Making kenaf seed tofu means getting each step just right for taste, nutrition, and texture. Figure 2 shows the clear difference between unsoaked seeds and those soaked for 12 hours, an important step in preparing the raw ingredient. The full process is outlined in Figure 3.

This new innovation turns kenaf seeds into soft tofu using a simple but effective method. The seeds are soaked for 12 hours, then lightly blanched to reduce any unwanted compounds. After blending with water and straining, the kenaf seed milk is mixed with egg yolk and a pinch of salt. The mixture is placed in heat-resistant containers and gently heated in a water bath at 80 °C for 8.5 minutes. Once cooled and chilled, the kenaf seed tofu is ready to enjoy, a smooth, protein-rich alternative with exciting potential for functional foods and plant-based diets.



Figure 2: Unsoaked and 12-hour soaked kenaf seeds



Figure 3: Simplified illustration of the kenaf seed tofu production process

WHY THIS MATTERS FOR SARAWAK

The development of kenaf-based food products presents multiple strategic benefits for Sarawak. By adding local value, raw kenaf exports can be transformed into premium, branded food items that enhance market competitiveness. These products also offer strong health appeal, delivering plant-based protein and healthy fats that meet the rising demand from wellness-focused consumers. Beyond health, kenaf contributes to economic diversification by expanding income sources beyond Sarawak’s traditional dominant crops, thereby strengthening resilience in the agricultural sector. Its rapid growth and eco-friendly characteristics further support sustainability initiatives and align with ESG goals. Most importantly, investing in kenaf positions Sarawak as an innovation leader, showcasing its ability to pioneer novel food technologies derived from local resource.

HOW KENAF SEED TOFU COMPARES TO SOY TOFU

Nutritional and storage benefits are key strengths of kenaf seed tofu. As shown in Table 1, it offers protein and fat levels comparable to traditional soy soft tofu. Most impressively, it maintains quality for up to 63 days in chilled storage, as observed in this short-term study. Figure 4 shows the kenaf seed tofu after 63 days of storage, still retaining its appealing texture and colour.

Table 1: Physicochemical Properties of Kenaf Seed Soft Tofu vs Soybean Soft Tofu

Physicochemical Properties	Kenaf Seed Soft Tofu	Soy Soft Tofu
Energy (kcal)	80.33	76.9
Crude Protein (%)	6.54±0.44	6.8±0.37
Crude Fat (%)	4.37±0.51	4.1±0.24
Ash (%)	0.83±0.13	0.7±0.40
Total Carbohydrate (%)	3.71±0.15	3.2±0.20
Total Soluble Solids (°Brix)	6.5±0.20	6.7±0.31
Colour	Airworthiness Certification	Airworthiness Certification
(L*a*b* colour space)	L*=83±0.41 a*=-1.4±0.29 b*= 6.5±0.32	L*=82.8±0.17 a*=- 1.42±0.20 b*=7.6±0.24
Hardness (g)	467.21±0.37	461.00±0.2
pH	6.2±0.18	6.4±0.15
Water Activity	0.76±0.50	0.76±0.25

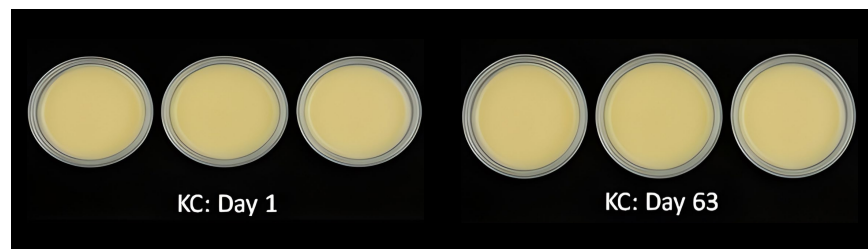


Figure 4: Kenaf seed soft tofu after 63 days of chilled storage

CONCLUSION

The rise of kenaf cultivation in Sarawak marks more than just the introduction of a new crop; it signals the beginning of an agricultural transformation. With strategic initiatives in Ulu Sebauh and Ulu Kelabat, backed by strong government commitment, kenaf is poised to become a pillar of the state's agro-economy.

Kenaf seed tofu proves that this plant's value goes far beyond fibre production. By tapping into the growing global demand for healthy, plant-based foods, Sarawak can position itself as both an agricultural and food innovation hub.

As the kenaf industry moves forward, its success will depend on sustainable practices, local community involvement, and continuous innovation. From the fertile fields of Bintulu to the dining tables of the world, kenaf has the potential to shape a greener, healthier, and more prosperous future for Sarawak.



FISTULAFIX: AN ALTERNATIVE DEVICE TO CURB VASCULAR ACCESS CLOSURE

SHAPING THE FUTURE OF DIALYSIS CARE IN BORNEO

**Fatin Nabilla binti Ahmad Tajuddin, Ting Kee Cheong,
Safrina binti Zainal Abidin and Mohammad Shahril bin Osman**

University of Technology Sarawak

Borneo, a land in which vibrant culture and rich biodiversity shape daily livelihood. When modern technology and healthcare immersed, another life changing innovation is unfolding. A story of veins, vessels and the medical breakthrough for thousands of kidney patients. In a class of its own, *FistulaFix* — an innovative award-winning medical device created, conceived and fabricated in Sarawak. *FistulaFix* will redefine post-dialysis care in Borneo eventually the world.

In clinics across Sarawak, Sabah, and beyond, healthcare workers still rely heavily on manual compression or improvised solutions. The results? Inconsistencies in care, discomfort for patients, and in some cases preventable complications.

This is where *FistulaFix* steps in — a homegrown innovation born from engineering expertise, medical insight, and a deep empathy for patients' daily realities.

THE CHALLENGE NOBODY TALKS ABOUT

In 2021, Malaysia had approximately 49,770 patients on dialysis. This number is based on data from the '29th Report of the Malaysian Dialysis and Transplant Registry'. The number of dialysis patients in Malaysia is increasing, with projections estimating over 106,000 Malaysians on dialysis by 2040

For more than 40,000 Malaysians who undergo regular haemodialysis, life revolves around three weekly clinic visits. The procedure relies on a surgically created arteriovenous fistula (AVF) — a robust connection between a vein and an artery that allows efficient blood flow to the dialysis machine.

While the regular dialysis process is a standard procedure, the aftercare stage has long been relied on method of case-by-case basis and generic solution. This open to a variable of options for advanced technology improvement. In clinics across Sarawak, Sabah, and beyond, healthcare workers often depend on manual compression, adhesive tape, or improvised clamps.

Post-Dialysis Pitfalls



With Malaysia's haemodialysis patients undergoing more than 6 million fistula closures annually, a slight percentage of poorly managed closures may lead to other complications. This could also translate into a heavy burden on patients, caregivers, and the healthcare system.

INVENTING WITH PURPOSE

Innovation is much appreciated if it is aligned with a greater purpose. Our team set out to design a medical device to ease the post-dialysis treatment for dialysis patients resulting this *FistulaFix*, a purpose-built, reusable medical device designed with patient outcomes and clinical efficiency at its core.

Unlike traditional methods, *FistulaFix* employs an adjustable clamping mechanism with a medical-grade silicone pad that delivers even, gentle but firm pressure over the puncture site, stopping bleeding without damaging surrounding tissue, ensures a comfortable, personalised fit, and the ergonomic design allows for one-handed operation — a game-changer for elderly patients or those in home-care programs.

Engineered in compliance with Malaysian Medical Device Authority (MDA) guidelines and global standards (ISO 13485, ISO 14971). This device is thoughtfully designed in a circular bangle-like shape, making it easy to handle with just one hand, and the cuff design keeps it securely in place, ensuring it doesn't slip or shift during usage. At the same time, it applies steady and efficient pressure directly over the puncture site,

effectively controlling blood flow and help the bleeding quickly and safely.

The end product will serve the intended results of less bruising, reduced risk of infection, and greater independence for patients.

RECOGNITION ON THE INNOVATION STAGE

In just one year, *FistulaFix* has achieved national and regional recognition:

- **Silver Medal** – *International Invention, Innovation & Technology Exhibition (ITEX 2025)*, Kuala Lumpur, May 2025, for originality, design, and engineering excellence.
- **Top 5 Pitcher** – Prestigious IBIEC pitching sessions, July 2025, recognising commercial viability and societal benefit.
- **Platinum Medal** – *International Borneo Innovation Exhibition & Competition (IBIEC 2025)*, Sarawak, July 2025, acknowledging its direct impact on regional healthcare needs.

The above-mentioned awards are the proof that this world-class medical device innovation is recognised. It is done right here, home grown in Borneo. A proud moment for Sarawak.

DESIGNED IN BORNEO, FOR THE WORLD

From CAD modelling in CATIA to 3D-printed rapid prototypes, *FistulaFix*'s development journey mirrors Borneo's growing role as a hub for medical technology. This is truly a team effort, a collective collaboration of great minds at work, engineers, researchers and healthcare professionals to come up with an innovation to increase efficiency. Multi-disciplinary at its best has produced this world-class medical device prototype that originated right here in Sarawak.



FistulaFix: An alternative device to curb vascular access closure

In true Bornean spirit, the design replicates TUMPA, a Ngepan Iban (female costume) wore as an accessory to complete the Iban traditional attire and of course it is also considered sustainability environmental impact – its reusable, reduces medical waste, and local production means lower costs and economic benefits for the region.

A RIPPLE EFFECT ON HEALTHCARE

The potential impact of *FistulaFix* extends far beyond a single device.

Clinically	Standardises wound closure, lowers complication rates, and improves patient outcomes.
Economically	Reduces hospital readmissions and disposable supply costs, while fostering Malaysia's medical manufacturing sector.
Socially	Empowers patients – especially in rural and remote communities – to manage post-dialysis care confidently at home.

As home haemodialysis and telemedicine gain traction in Malaysia, devices like *FistulaFix* will be essential in making treatment safe outside hospital walls.

SUSTAINABILITY DEVELOPMENT GOALS (SDGs)

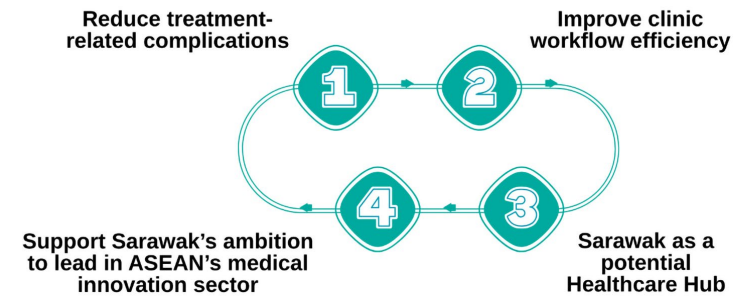
Beyond patient care, *FistulaFix* addresses a pressing healthcare sustainability issue – biomedical waste. Traditional post-dialysis care involves large volumes of single-use disposables, contributing to both environmental burden and recurring costs.

By replacing much of this waste with a reusable, sterilisable device, *FistulaFix* supports the United Nations Sustainable Development Goals (SDGs). The project supports Good Health and Well-being by improving the quality of care and reducing complications, while also contributing to Decent Work and Economic Growth by creating opportunities in local medical device manufacturing, research, and distribution, fostering high-value jobs and strengthening the regional economy. At the same time, it aligns with Industry, Innovation, and Infrastructure by enhancing local medical manufacturing capacity and driving technological advancement. Furthermore, it promotes Responsible Consumption and Production by reducing reliance on single-use consumables, lowering environmental impact, and encouraging sustainable healthcare practice. This approach balances healthcare advancement with environmental responsibility, ensuring that the future of dialysis care is not only safer but also more sustainable.

IMPACT FOR THE FUTURE OF BORNEO

In Borneo's rural interior, healthcare access can be challenging. For dialysis patients living far from urban centres, aftercare often falls to family members or the patients themselves. *FistulaFix* bridges this gap by offering a tool that is safe, easy to use, and reusable, providing peace of mind to patients and caregivers alike.

At a systemic level, adoption of *FistulaFix* could:



WHAT'S NEXT FOR THIS HEALTHCARE INNOVATION?

The theme “The Future of Borneo” is more than just advancement of technology, it is meant as an escalation of betterment of community livelihood. What *FistulaFix* has to offer is about resilience, self reliance and improvement of life quality plus longevity.

The combination of engineering precision and patient needs represents a future where Borneo will hail as the next leader in healthcare innovations. Sarawak aims to be a creator – setting a benchmark in medical device design, manufacturing and patient care. It is no doubt the product will prove a level of its own, to serve its higher purpose, increase efficiency and add affordable option to dialysis patients.

FistulaFix may be designed for Sarawakian first but it will be universal in its purpose. Chronic kidney disease affects more than 3 million dialysis patients worldwide, and the risk of post-treatment complications is common across all healthcare systems.

Malaysia's growing profile as a medical device manufacturing hub gives *FistulaFix* a strong foundation for global export. Strategic partnerships with international dialysis providers could bring this Sarawak-made solution to patients on every continent.



BRIDGING BORDERS, BUILDING FUTURES: KUUB'S DRIVE FOR BIMP-EAGA SUCCESS

EMPOWERING BORNEO THROUGH KNOWLEDGE, UNITY, AND INNOVATION

Fakhzan Haji Buang

Permanent Secretary General, Konsortium Universiti Universitas Borneo (KUUB)

Borneo, in the heart of Southeast Asia, is one of the world's last treasures of extraordinary biodiversity and rich cultural heritage. Its ancient rainforests are home to unique species, while its diverse communities maintain traditions passed down for generations. Yet, Borneo faces pressing challenges: education needs improvement, economic growth is uneven, environmental threats persist, and inclusive, sustainable development remains urgent.

To address these challenges, the Konsortium Universiti Universitas Borneo (KUUB) was established in 2023. KUUB is a collaborative alliance uniting universities from East Malaysia, Brunei Darussalam, and Indonesia's Kalimantan. The goal is simple but ambitious: to harness education, research, and community efforts to transform Borneo's future. By working together across borders, KUUB aims to empower communities, nurture local talent, and promote sustainable growth while respecting Borneo's unique culture and environment.

KUUB seeks to be Southeast Asia's leading higher education alliance, fostering partnerships that drive regional development. Guided by the principle of Borneo Bermartabat, which emphasises respect for culture, heritage, and dignity, KUUB also collaborates with regional and international partners to strengthen education, research, and sustainable development initiatives.

In 2024, KUUB became an official partner of the Brunei Darussalam-Indonesia-Malaysia-Philippines East ASEAN Growth Area (BIMP-EAGA). This recognition underscores KUUB's role in supporting BIMP-EAGA's goals of sustainable economic growth, better connectivity, and inclusive development. Backed by the Malaysian government and regional ministries, KUUB promotes knowledge sharing, joint research, and capacity-building to empower communities and foster a more resilient region.

A PLATFORM FOR COLLABORATION AND UNITY

BIMP-EAGA, launched in 1994, aims to accelerate development in one of Southeast Asia's most resource-rich but underserved regions. Success requires more than infrastructure and trade; it calls for collaboration, innovation, and a skilled population ready to tackle regional challenges.

KUUB unites 16 founding member universities across Borneo, creating a platform where institutions pool knowledge, coordinate projects, and address shared challenges. In the past year, members have launched joint programs, organised online forums on sustainable development, and published collaborative research on climate, economic resilience, and cultural preservation.

DRIVING RESEARCH AND INNOVATION

KUUB focuses on research that addresses Borneo's most urgent needs, including sustainable resource management, renewable energy, food security, health, and social wellbeing. Potential projects range from conserving biodiversity and controlling peatland fires to promoting sustainable tourism and rural entrepreneurship. Support from national governments ensures research is practical and aligned with regional strategies, helping communities thrive while protecting the environment.

BUILDING HUMAN CAPITAL

KUUB also prioritises education and training. Plans for a Cross-Borneo and BIMP-EAGA Student and Staff Mobility Scheme will allow students and faculty to study or work at partner universities, gaining a deeper understanding of regional cultures, economies, and ecosystems. Faculty exchanges, workshops, and training programs will further strengthen academic collaboration and cultural understanding. Initiatives in youth leadership, climate adaptation, digital literacy, and sustainable development aim to equip future generations with the skills needed to thrive in a connected world.

EMPOWERING COMMUNITIES

Indigenous and rural communities are central to Borneo's cultural heritage and environmental stewardship. KUUB actively involves them in research and development, respecting traditional knowledge and promoting sustainable livelihoods such as eco-tourism, handicrafts, and agroforestry. Special attention is given to supporting women,

young entrepreneurs, and emerging leaders. These efforts not only improve livelihoods but also preserve culture and strengthen local participation in regional development.

DIGITAL TRANSFORMATION AND ACCESSIBILITY

In today's digital world, KUUB emphasises digital literacy and education, especially in rural areas. By expanding online learning and training local entrepreneurs in e-commerce and digital marketing, KUUB aims to bridge the digital divide and provide equal opportunities across Borneo and BIMP-EAGA. These initiatives prepare communities for a modern, digitally connected economy while fostering inclusive growth.

CELEBRATING CULTURE AND REGIONAL SOLIDARITY

KUUB promotes cultural exchanges through festivals, workshops, and student programs. By celebrating Borneo's diverse traditions, the alliance strengthens mutual understanding and regional unity. Cultural events also support sustainable tourism and cross-border diplomacy, showing that heritage can drive both economic growth and social cohesion.

CHALLENGES AND FUTURE PLANS

Despite successes, challenges remain. Differences in education systems, logistical hurdles in remote areas, and limited research funding can slow progress. KUUB continues to work closely with governments, BIMP-EAGA, and development partners to overcome these barriers. Plans include expanding membership to institutions in the Philippines and creating a Research and Innovation Fund to support studies on climate, sustainability, and social equity.

ENVISIONING A SHARED FUTURE

Borneo's future depends on inclusive, sustainable, and knowledge-driven development. KUUB embodies this vision by uniting universities and communities across the region. Through research, education, community engagement, and policy advocacy, KUUB strengthens regional integration and ensures that no one is left behind.

By nurturing human capital, empowering indigenous communities, advancing digital literacy, and promoting cultural exchange, KUUB contributes to BIMP-EAGA's long-term vision of a thriving, resilient, and inclusive economic corridor. Investing in education, partnerships, and local communities today lays the foundation for a brighter

tomorrow for all of Borneo and its neighbors. These efforts also align with the United Nations' Sustainable Development Goals, emphasising quality education, economic growth, reduced inequalities, and strong partnerships.

BENGKEL INAUGURAL
KONSORTIUM UNIVERSITI UNIVERSITAS BORNEO (KUUB)
27 HINGGA 29 MAC 2023
THE WATERFRONT HOTEL, KUCHING, SARAWAK, MALAYSIA



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KUUB Inaugural Workshop (2023) co-organised with MEITD.



KUUB DoU Exchange Ceremony, Banjarmasin Kalimantan Indonesia (2023).



MINISTRY OF EDUCATION, INNOVATION
AND TALENT DEVELOPMENT SARAWAK

ISSN 3036-0293



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