DEVELOPMENT OF A SUSTAINABLE MIMOSA PUDICA PROCESSING UNIT FOR THE PRODUCTION AND COMMERCIALIZATION OF VALUE-ADDED PRODUCTS (MIMOPRO-project)

Applicant: Federal University of Technology Owerri (FUTO), Imo State

Thematic Areas: Agriculture and Food Manufacturing

BACKGROUND

Nigeria generates significant biomass waste, often utilized ineffectively, resulting in lost economic opportunities and environmental change. Research at the Federal University of Technology (FUTO) has focused on valorization and repurposing biomass wastes into value-added products. Such studies have applied thermal and bioconversion techniques to produce bioactive products, such as bioash, activated charcoal, biochar, feedstuffs, and organic manures for agricultural and food industry applications. However, available biomass materials face challenges due to their diverse nature and logistics costs. *Mimosa pudica* (MP)*,* a highly invasive weed in Nigeria, poses significant threats to agriculture and biodiversity, causing up to 90% crop yield losses due to its prolific seed production and resistance to herbicides. A proposed *M. pudica* valorization mode can harvest the weed and repurpose it into animal feedstuffs, additives, bio-fertilizers, and mushrooms, thereby providing a sustainable control method and converting it into value-added products. FUTO can therefore aims to co-create a robust MP processing unit with an interested SME to potentially drive innovation and economic development in Nigeria while supporting student training.

****PRELIMINARY RESULTS**

Feasibility of the project is evidenced by data from several FUTO's pilot thermal and bio-conversion studies.
Thermo-conversion studies: Thermal conversion of palm wastes yielded processed bioactive ash and activated charcoal improving egg laying performance by 10 - 12% (15.41 - 20.96% increase in profit from egg sales), and broiler chicken weight increase by 100 - 105 g (N154 - N165 increase in profit per bird) at seven weeks of lay (Nwogu et al., 2023; Ohanaka et al., 2025). Thermal conversion of invasive water hyacinth yielded 31-34% biochar and nano-enabled bio-fertilizers (Irewale et al., 2025) while crop trials showed 10 - 15% yield increases (Irewale et al., 2024; 2025). Bio-fertilizer and nano-enabled bio-nanobiofertilizers enhanced soil health and crop yield (Irewale et al., 2024; Onwudike et al., 2024).
Bioconversion studies: Bioconversion of composites of cassava root meal and palm kernel cake produced feeds enhanced broiler performance by a profit margin of N83.60 per Kg of broiler meat (Chukwukaelo et al., 2018) while in pigs, feed cost was reduced by 15.60 - 18.70 per Kg at similar growth rates with control diet (Aladi et al., 2021). Inclusion of fermented African tamarind stem bark in broiler diets also enhanced their organ weight, and carcass yield indicating improvements in productivity (Ogbuewu and Mbajiorgu, 2024). Okere et al. (2021) reported successful application of bioconversion approach to mushroom cultivation and development of organic fertilizers from various biomass wastes.

These studies confirmed the viability of the proposed thermal and bioconversion of *M. pudica,* while desk top studies yielded mostly phytochemicals and bioactivity studies of the weed (Adurosakin et al., 2023). These results validate MP's potential, with TRL 4-5 prototypes ready for scaling.

PROBLEM STATEMENT

Mimosa pudica (MP) is an invasive weed that severely impacts southern Nigeria's agriculture, causing up to 90% yield losses in crops like cassava and maize, thereby, threatening food security and biodiversity across the region (Uko *et al.,* 2020). Current control methods such as herbicide application, slash-and-burn, and hand-pulling are ineffective due to MP's prolific seed production, rapid regrowth, and herbicide resistance (Uko *et al.,* 2020). Unchecked expansion has led to environmental degradation, ultimately compromising the sustainability of farm lands. The under-utilization of MP as a biomass resource represents a missed economic opportunity, since southern Nigeria generates vast amounts of biomass from the weed but lacks integrated systems to convert it into value-added products. High logistics costs

and decreasing volume of researched and adopted biomass feedstocks further hinder sustainable bio-processing. This project addresses these challenges by developing a sustainable MP processing unit (MPPU) at FUTO to transform the invasive weed into commercially viable products, reducing agricultural losses and environmental harm while fostering economic growth in Nigeria.

PROJECT OBJECTIVES

To develop sustainable innovative processes, technologies and expertise for transforming *M*. *pudica* into value-added products

The specific objectives are to:

-Conduct baseline survey on MP distribution across 50 sites in southeastern Nigerian states

-Develop and optimize MP thermal conversion into processed bioash, and nano-enabled biochar, and activated carbon

-Apply bioconversion techniques to transform MP into feedstuffs and bio-fertilizers

-Determine the properties, safety, and efficacy of MP-derived products using laboratory analysis, animal and crop trials

-Assess the environmental impacts of harvesting and processing MP

-Develop commercialization strategies for scaling production

-Train key stakeholders on MP products development and applications

****ALIGNMENT WITH NASENI OBJECTIVES**

This project aligns with NASENI's mandate of to enhance manufacturing capacity and drive industrialization under the Renewed Hope Agenda. It develops cost-effective equipment for repurposing MP into several value-added products, promoting eco-friendly products through the valorization of the invasive weed *M. pidica*. The initiative supports NASENI's current indigenous technological advancement goal under the principles of "creation, collaboration and commercialization" for industrial growth, and asset restoration, positioning the agency as a leader in technology transfer, and Nigeria as a pioneer in green bio-products innovations.

****INNOVATIVENESS AND NOVELTY**

This project introduces a pioneering integrated bio-refinery system for *M. pudica* (MP), an invasive weed causing up to 90% crop yield losses in Nigeria, by transforming it into multiple value-added products through thermal conversion (pyrolysis for nano-activated carbon and biochar), bioconversion (solid-state fermentation for feeds and bokashi composting for fertilizers), bio-digestion for biogas, liquefaction for biodiesel, and fiber extraction for industrial composites. The novelty lies in nano-enabling biochar and activated carbon for enhanced bio-fertilizer and animal feed additive applications, achieving 15-20% improvements in soil nutrient retention and animal growth, while incorporating *Pleurotus tuber-regium* mushroom production using MP as key substrate, with spent residues repurposed as bio-fertilizers, a first in Nigerian agro-waste valorization. Unlike scattered global efforts on MP for energy or phytochemistry, this multi-product, circular economy model addresses invasive weed control holistically, reducing environmental harm from herbicides and slash-and-burn, with potential to mitigate biodiversity threats and generate ₦50-100 million annually. The initiative leverages FUTO's expertise in biomass conversion, advances cutting-edge, low-cost technologies tailored for biomass materials like MP, thereby impacting food security (SDG 2), sustainable economic growth and economic progress (SDG 8 and 12), while mitigating environmental impacts (SDG 13) in Nigeria.

****COMMERCIAL VIABILITY**

A Letter of Intent (LOI) has been obtained from Olorun Osun Farms (Nig) Ltd (OOFL), 120 Wetheral Road, Owerri, Imo State (Email: olorunosunfarms@gmail.com). Established in 1996, (RC: 1043223) the Company is involved in Agricultural and Technology solutions, supplying farmers and agribusinesses with nutrient-rich animal feeds, farming equipment, inputs and consultancy. Through the Managing Director Mr. Fagbolu, I.K. the company is a member NIPOFERD Consortium, a multi-stakeholder partnership of FUTO researchers, Poultry Association of Nigeria (PAN) and All Farmers Association of Nigeria (AFAN) Imo state

branches, indicating an enduring industry-researcher engagement. OOFL has also entered into off-take agreements with potential buyers of the MP-derived products (documents are attached).

****TECHNOLOGY READINESS**

Currently at TRL 5 (validated in lab environment), the project builds on FUTO's publications (e.g., 10 papers on biomass conversion) and patents (e.g., pending for nano-biochar process). Prototypes for pyrolysis and fermentation have been tested in pilots, with data from 2017-2025 trials showing efficacy. The proposal advances to TRL 7 (system prototype in operational environment) via the MP Processing Unit (MPPU), with full commercialization (TRL 9) by Month 36 through SME integration. Again, FUTO's interdisciplinary team of more than 10 researchers, supported by NASENI collaborations, ensures logistical and technical readiness.

****SCALABILITY**

FUTO's track record in technology transfer equips the **MIMO**PRO project for practical implementation, as seen in prior commercialization of biomass-derived feeds and fertilizers adopted by local SMEs and farmers. Therefore, beyond the pilot stage, scalability will involve replicating the MPPU model in five additional sites across southern Nigeria by Year 5, partnering with NASENI for national rollout to 10 universities. Modular designs allow 5-fold expansion increasing output 5-fold with ₦100 million investment from revenues. Technology transfer to 5 SMEs via franchising, supported by policy advocacy, ensures nationwide adoption, targeting 5% of Nigeria's bio-fertilizer and feed market by 2030.

PROJECT ACTIVITIES

Work Package 1: Thermal and Biological Conversion of MP into Feed Additive and Feedstuff

Baseline survey of MP Biomass Availability: A comprehensive baseline survey will be conducted across 50 sites (10 per state) in Abia, Anambra, Ebonyi, Enugu, and Imo. Stratified random sampling will select sites representing farmlands, forests, roadsides, and disturbed areas. Field methods include GPS mapping, quadrat sampling (1 m² plots, n=20 per site) will be used to determine infestation density, and biomass estimation via destructive harvesting. Data generated will be analyzed using GIS software (ArcGIS) and SPSS for statistical trends and the biomass potential (kg/ha) to inform harvesting strategies for sustainable supply of 500-1000 kg/month per state.

Infrastructure and equipment: A 50 m² processing shed with ventilation and storage for biomass and products will be built, while install solar dryers and power backup, rotary kiln, fermenters, hammer mill, autoclave, and CBC analyzer will be fabricated or purchased.

Biomass collection and preparation: MP will be harvested from infested sites in targeted southeastern states using manual cutting (1000 kg/month), air-dry (solar dryers, 40°C, 48 hours), and ground to 1-2 mm particles using a hammer mills.

Thermal conversion: The MP samples will be subjected complete burning to produce bioash, which will be weighed, soaked in water for 24 hours, and the solution decanted while the solid fraction will be dried and weighed to produce processed low K and Na bioash (PBash). MP will also be pyrolysis in a rotary kiln (500-700°C, 2 hours) and steam activated to produce activated carbon (AC) and nano-enabled by ball milling (planetary mill, 300 rpm, 6 hours) to create nano-AC (particle size <100 nm). The PBash will be characterize using AAS and the nano-AC using SEM, FTIR, and BET analyzers for surface area and porosity.

Bioconversion (SSF): Pulverized whole MP plant (500 kg batches) will inoculated with yeast, *Saccharomyces cerevisiae* (10^6 CFU/g) and 5% molasses in solid-state fermenters (30°C, 7-14). The product will be re-ensilage for 10 days in anaerobic silos, dried and milled to produce fermented MP (FMP).

Laboratory analysis and animal trials: The PBash, nano-AC and FMP will be tested for nutrient content (carbon and mineral concentrations via AAS, proximate analysis via Kjeldahl method), anti-nutritional factors (HPLC), and microbial safety (plate count). Animal trials will be conducted with 600 broilers for PBash and nano-AC as additives (8-week feeding, 0.5-2% inclusion), and 48 pigs for feedstuff (12 weeks feeding, 10-30% inclusion) to measure growth performance (feed intake, weight gain, FCR), carcass yield (dressed percentage), and hematology (CBC analyzer).

Exhibitions and outreach: One agricultural expos will be organized (Owerri) to showcase products, targeting 200 attendees. The animal production benefits will be demonstrated via live poultry and pig trials, while 500 product samples will be distributed.
Scientific publications: Three journal articles on PBash, nano-AC efficacy and FMP optimization will be published, while findings will also be presented at one international conference.
Commercialization and promotion activities: 100 farmers, and 10 SMEs will be surveyed to assess demand and pricing for the products and business models developed with cost-benefit analysis (Excel, NPV/BCR). NAFDAC certification will be secured, while partnerships will be three agribusiness SMEs (Olorun Osun Farms Ltd and others) formed for co-production, establishment of supply chains and regional distribution. Again, pilot sales will be carried out through the SMEs in the targeted states and during three workshops (100 farmers and extension agents total). Digital campaigns will be created using social media (Facebook, WhatsApp, Instagram), 1000 flyers will be produced and distributed at national trade fairs. The process of licensing the technology to two startups via FUTO's Tech Transfer Office will be initiated.

Work Package (WP) 2: Thermal and Biological Conversions for Bio-fertilizers and Mushroom Production
Biomass preparation: MP will be collected and dried (800 kg/month), ground to 2-3 mm particle size.
Thermal conversion: Whole MP will be carbonized in a fixed-bed carbonizer (400-600°C, 4 hours) to produce biochar, nano-enabled via ball milling (<100 nm) to produce nano-biochar (nano-BC) and characterize with XRD, FTIR, and soil nutrient assays (AAS).
Bioconversion (Bokashi): Whole MP (400 kg batches) will be pulverized, mixed with animal manure (poultry), soil, biochar, and wheat offal (33.33 x 33.33 x 23.81 x 4.76 x 4.76%) and molasses and inoculated with effective microorganisms (Yeast, 10^7 CFU/g) using bokashi technique (aerobic, 14 days with regular turning). Thereafter, the organic manure will be stabilized in aerated bins for 7 days to produce bokashi organic manure (BOM) .
Mushroom (*P. tuber-regium*) cultivation: Whole MP will be dried, ground into coarse particles and blended with rice hull to form a substrate (300 kg) and inoculated with *P. tuber-regium* spawn (5% w/w) in a controlled mushroom chamber (25-30°C, 80% humidity, 120 days). Mushroom tubers or sclerotium will be harvested (expected yield: 20-25% substrate weight) and processed for food market. The spent substrate will be processed as spent MP (SMP) biofertilizer after sterilization (autoclave, 121°C, 15 min).
Laboratory Analysis: The nano-BC will be analyzed for CEC, pH, and nutrient retention (spectrophotometer); BOM and SMP will be tested for NPK content (Kjeldahl, flame photometry) and microbial activity. Field trials will be conducted with leafy vegetables (pumpkin, water leaf, garden egg, pepper, 450 m^2, 3 sites) to assess effects on yield (10-20% increase) and soil health (carbon content, microbial biomass).
Infrastructure and equipment: A 40 m^2 composting facility with anaerobic tanks and aeration units will be constructed, while water supplied from processing. The needed equipment such as a fixed-bed carbonizer, bokashi fermenters, and soil testing kits will be procured.
Exhibitions and outreach: One MP-biofertilizer (MP-Bioferts) and the *P. tuber-regium* expo will be organized in Owerri targeting 150 attendees, and demo plots showcased. 500 kg free samples of the organic fertilizers will be distributed to farmers.
Scientific publications: Three journal articles on nano-BC, BOM, *P. tuber-regium*/SMP production, will be published, while findings will also be presented at one international conference.
Commercialization and promotion activities: 50 farmers and 5 Agro-Tech dealers will be surveyed for market demand, and pricing models developed for the MP-BioFert products. Partnership agreements will be struck with two local fertilizer companies for blending, while SON certifications will be secured. Again, pilot sales (500 kg) of the products will be carried out through Agro-Tech dealers to test the market, and the outcome used to sign bulk supply contracts with two dealers. Two farmer field schools (50 participants) with extension services will be conducted. The products will also be promoted via radio and online adverts (Instagram and Facebook).

Work Package 3: Infrastructure Development and Project Management

Establishment of project building: The building will be provided by FUTO, upgraded for the project purpose and the surrounding secured with wire mesh fence (1.5 m height, galvanized steel, including gates for access control). The building will comprise offices (for project team and administration), a product display shop (with shelving and display cases for MP-derived products), a research lab (equipped for basics like pH meters and microscopes), and a meeting room (capacity 20, with audiovisual setup).

Procurement: Fencing material, office/lab furnishings (desks, computers, lab benches, stools etc), biomass pre-conditioning equipment solar dryers, jaw crusher, vibrating sieves) will be sourced and procured.

Planning and organization of project meetings: Quarterly steering committee meetings (4/year, 20 participants) and monthly team meetings (12/year, 10 participants) will be scheduled. The meeting agendas, minutes, and reports will be prepared in addition to virtual/in-person meetings tools like Zoom and Microsoft Teams.

Project monitoring and evaluation (M&E): M&E framework will be developed with KPIs (e.g., products development progress, budget adherence). Bi-monthly site inspections, mid-term evaluation, and final audit will be conducted. Tools like Gantt charts (MS Project) and surveys for stakeholder feedback will be used, while progress reports will be prepared for NASENI.

Risk management and compliance (RMC): For RMC, environmental impact assessments (EIA) will be performed for site and donated building, ensuring compliance with Nigerian safety standards. Ten members of the project team will be trained on project management (PMP basics), while 2 personnel will be drawn from FUTO pool and 4 CCTV camera units installed to secure the unit.

Documentation and reporting: Digital records of all project activities, including budgets, and outputs will be maintained and used for the preparation of relevant reports.

EXPECTED RESULTS

Short-term Outcomes

-Baseline survey conducted, MP distribution mapped across southeastern Nigeria
-MP processing unit established, producing feedstuffs, MP-Biofertilizers and mushroom
-Products' efficacy validated, improving poultry/pig growth (15-20%) and crop yields (10-15%)
-150 stakeholders trained, gaining 80% knowledge in MP processing
-Cost-benefits analyzed, achieving BCR >1.5 for all products
-Six journal articles published, four conference presentations made

Long-term Impacts

-MP infestation reduced by 20-30%, enhancing agricultural productivity and biodiversity
-MP processing model adopted by universities and SMEs, increasing Nigeria's bioeconomy contribution
-₦30-50 million annual revenue generated, supporting rural employment
-MP processing integrated into national policies, promoting green technology and climate resilience

EXPECTED OUTPUTS

1. Physical products: 500 kg nano-AC, 1000 kg FMP, 500 kg PBash, 300 kg nano-BC, 500 kg BOM and SMP, 125 kg mushroom tubers

2. Reports and data: Baseline survey report on MP infestation and biomass availability, cost-benefit analysis report (BCR >1.5 for all products), efficacy validation reports (lab, animal, and field trials)

3. Training and capacity building: Training materials (manuals, videos, workshop kits) for 150 stakeholders, 80% knowledge gain in MP processing among stakeholders

4. **Commercialization outputs**: Three patented processes (nano-AC, nano-BC, FMP), NAFDAC/SON certifications, supply contracts with five SMEs

5. Scientific outputs: 6 peer-reviewed articles published, presentations at 4 conferences on MP-derived products

KEY PERFORMANCE INDICATORS (KPIS)

1. 90% yield efficiency in thermal and bioconversion processes achieved.
2. 15%+ improvement in animal growth and 10-15% increase in crop yields achieved.

3. 150 stakeholders trained with 80% demonstrating proficiency
4. BCR >1.5 and ROI >20% for all products achieved
5. 20% reduction in MP coverage and 50% cut in herbicide use achieved
6. Six articles published and papers presented at 4 conferences.

IMPACT

1. **Economic**: Generates ₦50-100 million annually from product sales, creating 500+ jobs for farmers and SME workers, reducing import dependency for feeds and fertilizers.
2. **Environmental**: Controls MP spread, reducing 90% crop losses and herbicide-related pollution; and enhances soil carbon sequestration (10-15% increase)
3. **Social**: Empowers rural communities through training and income opportunities, improving food security for 1 million+ people via enhanced agricultural output
4. **Policy**: Informs national strategies for invasive species management and bioeconomy, aligning with NASENI's industrialization goals and SDGs 2, 8, 12, and 13

SUSTAINABILITY BEYOND PROJECT LIFE

1. The bio-refinery serves as a permanent research and training hub, supported by revenue from product sales and licensing to SMEs
2. Scalable commercialization through cooperatives ensures long-term profitability, with reinvested profits funding facility maintenance
3. Ongoing MP harvesting reduces ecological damage, while animal feeds/additives and biofertilizers promote sustainable farming
4. Continuous farmer training via extension services and online platforms ensures adoption, with SMEs scaling production beyond the project's life
5. Advocacy for MP processing inclusion in Nigeria's Agricultural Policies sustains impact, supported by partnerships with NASENI

PROJECT RISKS

Type of risk	Risk	Mitigation
Technical risk	Inconsistent biomass quality or equipment failure (e.g., pyrolyzer malfunction)	Rigorous preprocessing standards and regular maintenance schedules; procure high-quality equipment with warranties
Market risk	Low farmer/SME adoption due to cost or awareness barriers	Subsidized pilot sales, extensive workshops, and digital marketing campaigns
Environmental risk	Overharvesting MP could disrupt local ecosystems	Implement controlled harvesting protocols and monitor biodiversity impacts
Regulatory risk	Delays in NAFDAC/SON certifications	Early engagement with regulators and pre-submission compliance checks
Financial risk	Budget overruns due to fluctuating material costs	Detailed cost forecasting and sourcing local materials to stay within the total budget

TOTAL BUDGET ESTIMATE FOR THE PROJECT

Work package	Items	Explanation	Amount (₦)
WP1 Feed additives & feedstuff production	Equipment	Rotary kiln (₦1M), Fermenters (₦0.5M), Hammer mill (₦1M), Autoclave (₦0.5M), and CBC analyzer (₦1M)	4,000,000.00
	Infrastructure	50 M^2 biomass processing and storage shed (₦2M) Solar dryer (₦0.5M), power backup (₦0.5M)	3,000,000.00
	Personnel		3,800,000.00
	Materials/testing	Biomass collection/preparation, thermal conversion, bio-conversion, lab analysis, animal trials (600 broilers/60 pigs)	4,300,000.00
	Survey	Baseline survey of 5 states (Imo, Abia, Anambra, Ebonyi, Enugu)	1,500,000.00
	Commercialization/ exhibitions	One agricultural expos to targeting 200 attendees, distribution of 500 product samples, NAFDAC registration and online activities	2,400,000.00
	Publications/ Conferences	Two scholarly articles and One national conference attendance	1,000,000.00
	Sub-total		**20,000,000.00**
WP2: Biofertilizers & Mushroom Production	Equipment	Fixed-bed carbonizer (₦1.6M), bokashi fermenters (₦0.5M), Soil testing kits (₦0.5M)	2,600,000.00
	Infrastructure	40 m^2 composting facility (₦1.8M), water supply for processing (₦0.3M), Mushroom growing chamber (N0.5)	2,000,000.00
	Personnel		2,500,000.00
	Materials/testing	Biomass preparation, thermal bioconversion, lab. analysis, and field trials	3,000,000.00
	Commercialization/ Exhibitions	One agricultural expo targeting 150 attendees, distribution of 500 product samples, SON registration, farmer field school, online activities	2,400,000.00
	Publications/ Conferences	Two scholarly articles and one national conference attendance	1,000,000.00
	Sub-total		**13,500,000.00**
WP3: Project Management Activities	Site Clearing and fencing	Fencing of site, wire mesh (2.5 m height), steel gate	2,000,000.00
	Main building repurposing	Partitioning of building, products display shop, security post	2,000,000.00
	Procurement	Building materials, (₦1.5M), and office/lab furnishings (₦2M), CCTV (N0.5)	4,000,000.00
	Personnel		2,000,000.00
	Meetings and M&E	Bi-monthly/mid-term evaluation, final audit, stakeholder survey feedback, final reports	1,500,000.00
	Training and compliance	Quarterly committee meetings, monthly team meetings, virtual/in-person formats	1,800,000.00
	Security	2 personnel	1,700,000.00
	Sub-total		**15,000,000.00**
Total			**48,500,000.00**
Contingency		2.5% of subtotal for inflation/risks	1,212,500.00
Grand Total			**49,712,500.00**

WORK PLAN (24-MONTH TIMELINE)

The work plan is structured in phases, with overlapping work plans (WPs) to ensure integration. Key milestones include infrastructure completion (Month 4), Prototype products (Month 8), Lab validated product (Month 12), and full commercialization (Month 16). Monitoring via WP3 occurs throughout

Work Phases (Months)	**WP1**	**WP2**	**WP3**	**Milestone**
Phase 1 (1 - 4): Initiation & infrastructure setup	Baseline survey, biomass collection, equipment procurement for thermal/ bioconversion	Pre-processing setup, procurement for biochar, composting, mushroom	Repurposing of building, fencing, procurement	Site ready; baseline survey completed
Phase 2 (5 - 8): Development & initial processing	Pyrolysis, FMP processing, initial lab analysis	Carbonization, bokashi composting, *P. tuber-regium* cultivation; soil trials start	Equipment installation, first project meetings and M&E framework	Prototype products (Additives, feedstuff, MP-Bioferts) produced; mid-term M&E report
Phase 3 (9 - 12): Optimization & Testing	Animal trials, efficacy testing	Field trials for MP-Bioferts (nano-BC, BOM, SMP); mushroom yield optimization	Ongoing M&E, quarterly meetings, compliance checks, stakeholder engagements	Lab-validated products; stakeholder training begins
Phase 4 (13 - 16): Commercialization & Dissemination	Commercialization activities, exhibitions, publications	Market surveys, pilot sales, publications	Mid-term evaluation, annual reports; risk management audits	Certifications applied/obtained; initial sales and adoptions
Phase 5 (17 - 20): Scaling & Impact Assessment	Scale production, expand supply chains, monitor environmental impacts	Scale production, expand supply chains, monitor environmental impacts	Bi-monthly inspections, stakeholder feedback surveys: Scale production, expand supply chains, monitor environmental impacts	Benefit Cost Ratio (BCR) analysis; technology transfers to 5 SMEs
Phase 6 (21 - 24): Sustainability and Closure	Full commercialization, franchising, long-term sustainability plans	Full commercialization, franchising, long-term sustainability plans	Final audit, documentati on, policy briefs: Full commercializ ation, franchising t; long-term sustainability plans	Project closure report; revenue streams establishe for FUTO MP-unit

KEY PERSONS IN THE RESEARCH TEAM

Person Qualification	Role	Experience, Skills and Activities in the Project
Prof. Ifeanyichukwu Ogbuewu, PhD	Principal Investigator	Professor of animal physiology and nutrition: Teaching and research at FUTO (20+yrs): Skills in livestock feed development, data analysis, livestock advisory service (LAS): Will oversee all project activities, WP1 Feed additives & feedstuff production; WP2 Biofertilizers and Mushroom Production; WP3 Project Management Activities
Prof. Emeka Oguzie, PhD	Co-Principal Investigator	Professor of electrochemistry and materials science: Teaching and research at FUTO (20+yrs): Skills in bioresources utilization, remediation/bioremediation, project conception and execution: Will be involved in WP2 and WP3
Prof. Charles Okoli, PhD	Co-Reseaecher	Professor of animal management and health Teaching and research at FUTO (20+yrs): Skills in biomass conversion, animal diet development, project conception and execution, and livestock advisory service (LAS): Will be involved in WP1 and WP3
Dr. (Mrs) Chioma Ahukamere, PhD	Co-Researcher	Reader, soil and land use planning; Teaching and research at FUTO (12+yrs): Skills in biomass waste conversion, organic fertilizer production, carbon sequestration; Will be involved in WP2 and WP3
Dr. Nnayere Aladi, N.O. PhD	Co-Researcher	Reader, Animal products and nutrition, Teaching and research at FUTO (12+ yrs): Skills in livestock diet development, animal products quality assessment, livestock advisory service (LAS): will be involved in WP1
Dr. Samuel Okere, PhD	Co-Researcher	Senior Lecturer, Mycology and Plant Pathology: Teaching and research at FUTO (10+yrs): Skills in bio-conversion of agro wastes, fungal biotechnology, data analysis: Will be involved in WP2
Dr(Mrs) Nwakwasi, PhD	Co-Researcher	Reader, Agricultural extension and rural sociology: Teaching and research at FUTO (12+): Skills in farmer participatory studies, agricultural extension and advisory service delivery; Will be involved in WP1 and WP3

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