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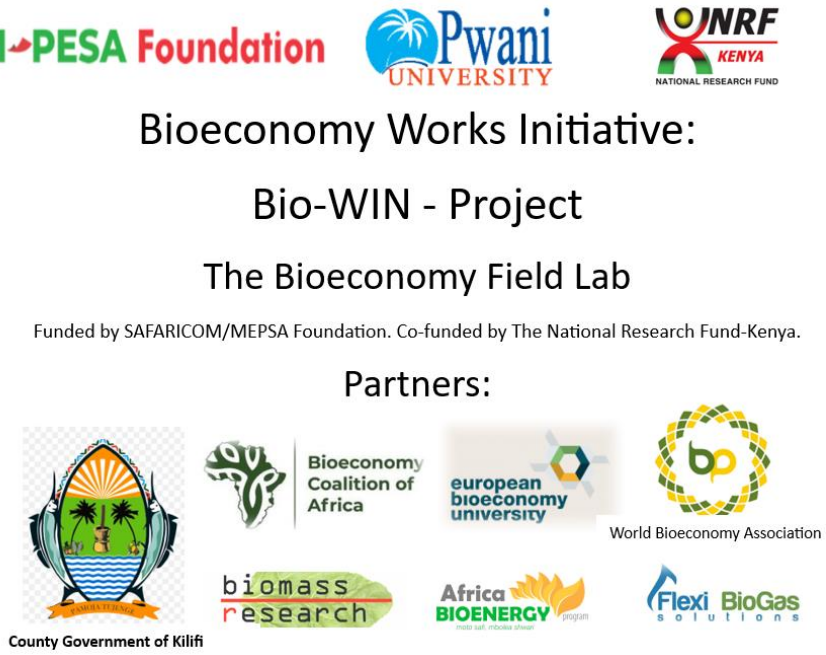


Figure 1. Proposed Billboard

Executive Summary

Pwani University has transformed its Integrated Biogas Demonstration Unit, funded by the National Research Fund and Co-Funded by Pwani University, into a state-of-the-art Bioeconomy Field Lab and Innovation Hub. This initiative aims to support climate-smart solutions, circular economy principles, and skills development through applied research and local community engagement. Already, MPESA Foundation has pledged to support the Initiative for infrastructure, equipment procurement, system upgrades, and the establishment of Bioeconomy Museum of the Future.

Hosted Projects

1. Agroval – AgroIndustrial Waste Valorisation:
   Partners: Technical University of Denmark (DTU), Nelson Mandela African Institute of Science and Technology (NMAIST), Addis Ababa University (AU)
   https://drp.dfcentre.com/project/agroval-sustainable-valorisation-of-agro-industrial-residues-through-integration-of-food-bioproducts-and-bio-energy-production/

   Funded by: DANIDA (DFC)

2. Bio-KE – National Bioeconomy Education and Policy Development in Kenya:

   Partners: The University of Hoheneheim (UHOH), Techncial University of Denmark (DTU), Ministry of Agriculture, The National Commission for Science, Technical and Innovation (NACOSTI), The Commission for University Education, The National Research Fund, Egerton University, Kenya Universities and Colleges Central Placement Service, Chuka University, Africa BIOENERGY PROGRAMS LIMITED, International Development Institute-Africa Limited, AGRI-KILIMO CONSULTANCY LIMITED, Bioeconomy Coalition of Africa (BioCA-SCIFODE).

   Funded by: European Union (Erasmus+ Programme, Strand 3) National System Change

3. The Integrated Biogas Unit
   Partners: Africa Bioenergy Programmes Limited, Biogas International, and Biomass Research (The Netherlands)

   Funded by: National Research Fund and Pwani University

Bio-WIN Objectives

- Upgrade biogas infrastructure to manage urban organic waste.
- Develop a Bioeconomy Wing for applied bio-resource testing and value addition.
- Construct workshops and labs for bio-product manufacturing.
- Promote community learning and TVET-skills development through hands-on engagement.
- Establish a Centre of Excellence in Bioeconomy Innovations.

Justification: Theory of Change

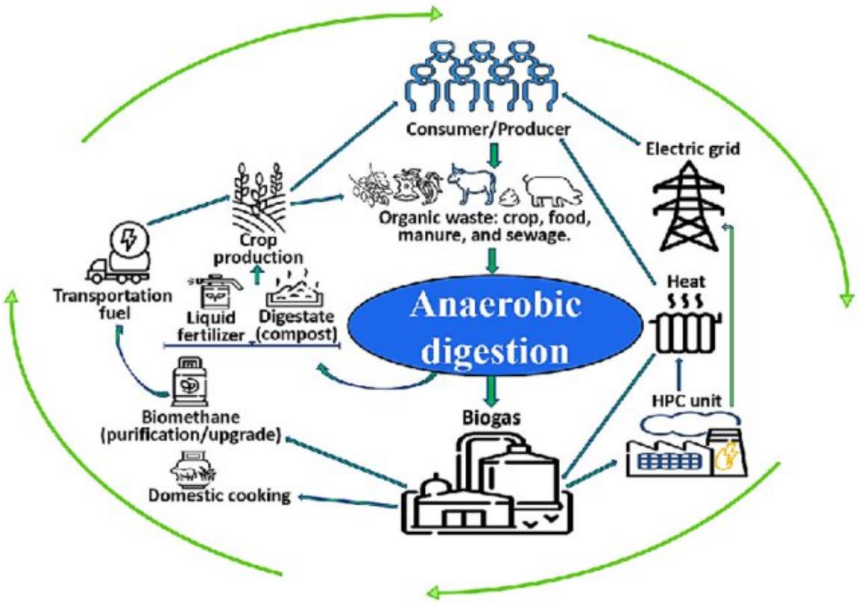
Theory of Change: Circular Bioeconomy System for Food Waste Valorization

1. **Input Stage (Problem Statement)**

- *Current Reality*: Kilifi County generates 200+ tons/day of organic waste with <5% recovery rate
- *Key Challenges*:
    - ✓ Waste accumulation → GHG emissions (CH_4)
    - ✓ Soil degradation from chemical fertilizers
    - ✓ High cost of livestock feeds

2. **Intervention Components**

- *Technological System at a futuristic Scale (PU to focus on Bioenergy and Biofertilizer)*



3. **Pathways to Impact**

3.1 Energy Circularity

- Process: 1 ton waste → 120m³ biogas (≈60kWh electricity)
- Evidence: ADEME studies show 40% energy recovery efficiency
- Impact: Displaces firewood/LPG use in campus kitchens

3.2 Nutrient Recovery

- Bioslurry processing:
    - ✓ N-P-K content: 2.1-1.4-0.6% (FAO standards)
    - ✓ Pelletizing increases shelf-life by 6 months

3.3 Feed Production

- BSF conversion rate:
    - ✓ 10kg waste → 1kg larvae (70% protein)
    - ✓ Replaces 30-50% of poultry/fish feed imports

4. **System Metrics**

A **40 m³ biogas digester** can generate **120–180 kWh/day** of usable energy in biogas, sufficient to:

- Cook for 20–30 households
- Power a generator (~10 kW for 10–15 hours)
- Run small-scale industrial equipment (dryers, chillers, etc.)
- Replace up to 15 L of diesel or 15 kg of LPG per day

Flow	Input	Output	Conversion Rate	Value Created
BSF Unit	100kg waste	15kg larvae + 40kg frass	55% conversion	KES 3,000 feed value
Biochar	50kg waste	15kg biochar	30% yield	KES 1,500 soil value

5. **Scalability Factors**

- *Replicability*: Modular design allows 20-80m³ biodigester variants
- *Labor Impact*: 1 unit creates 5 direct jobs (operators, BSF farmers)
- *Carbon Credits*: Verified 2.3 tCO_2e/ton waste diverted (Gold Standard)

6. **Validation Evidence**

- Case Study: JKUAT Biogas Project (2019) showed 18-month ROI
- RCT Data: TVET trainees increased farm incomes by 35% (KNBS 2023)
- Lifecycle Analysis: Net positive EROI (Energy Return on Investment) of 8:1

7. **Risk Mitigation**

- *Technical*: Dual feeding (BSF + biodigester) ensures system redundancy
- *Market*: Pre-agreements with 10 local farms for biofertilizer offtake
- *Financial*: Revenue diversification (energy sales + carbon credits)

This theory demonstrates how 90%+ material circularity can be achieved through integrated bioprocessing, with measurable economic and environmental returns. The system's innovation lies in its cascading resource recovery, where each waste stream becomes input for another value chain.

Proposed Components and Specifications

ITEMIZED BUDGET WITH TECHNICAL SPECIFICATIONS

Component	Description	Technical Specifications	Qnty	Unit Cost (KES)	Total Cost (KES)
Billboard Signage	Branding at entrance	3m x 6m digital printed, steel frame, weatherproof	1	200,000	200,000
Organic Shredder	Waste pre-processing	ECO-Green 3000: 10HP motor, 5-10T/day capacity, 300-400kg/hr throughput, safety guards	1	450,000	450,000
Organic Waste Collection Bins	Community waste points	240L HDPE bins with wheels and lids, UV stabilized	30	10,000	300,000
Tuktuk Organic Waste Carrier	Mobile collection unit	150cc 3-wheeler with 1.5T payload capacity, modified waste compartment	1	930,000	930,000
Spare Parts for Biodigesters	System rehabilitation	Includes pumps (2HP), piping (50mm HDPE), valves, gas holders	-	-	600,000

Component	Description	Technical Specifications	Qnty	Unit Cost (KES)	Total Cost (KES)
Large-Scale Biodigester	Primary processing unit	FRP construction, 80m³ capacity, 3-chamber system, gas collection	1	3,500,000	3,500,000
Bio-Economy Museum	Interactive exhibition	120" smart screen, 4 VR stations, 5 interactive displays	1	1,200,000	1,200,000
Office Extension	Administration building	8m x 5m prefab structure, 2 offices, 1 meeting room, 2 washrooms	1	1,500,000	1,500,000
Internet Installation	Digital infrastructure	Fiber optic connection, 10mbps, smart screen, 5 tablets	1	400,000	400,000
TVET Complex Equipment	Lab instruments	Includes: - pH meters (5) - BOD analyzers (2) - Autoclaves (2) - Microscopes (3)	1 set	6,000,000	6,000,000
Workshop Tools	Fabrication equipment	Includes: - Welding machines (2) - 3D printers (2) - Bench drills (3) - PPE kits (20)	1 set	4,000,000	4,000,000
Biofertilizer Equipment	Production line	Includes: - Biochar kiln (200kg/day) - Pelletizer - BSF rearing trays (20) - Dryer	1 set	3,200,000	3,200,000
		GRAND TOTAL			**22,280,000**

The Museum of the Future uses Futures-Thinking concepts

The Museum will use Futures Thinking Concepts to invite thought-provoking experiential learning to visitors to allow for a powerful emotional engagement with the role of Bioeconomy Approaches on combating Climate Change (see Video Links and Fig 2) **https://youtu.be/0GjAHJSHDTs?si=mEkZxt7H-7mjRgDK and engages Citizens to live in the Future through the Virtual Reality Museum https://www.youtube.com/watch?v=mH3sJbscH6w**

Figure 2. https://www.theeastafrican.co.ke/tea/magazine/from-a-smelly-dumpsite-to-a-relaxing-public-park-the-alluring-tale-of-kibarani-1437208

Linkages and Partnerships

The Bioeconomy Stakeholder Map includes Local and International Partners that support the development of Biobased Solutions as strategies for the management of Waste and combating climate change. Pwaini University has recently secured a Grant from the European Commission to spearhead the Development of the Bioeconomy Education and Policy Framework in Kenya, Acronym – Bio-KE Project. We believe Safaricom/MPESA Foundation is a Critical stakeholder in this space. By supporting Pwani University to develop the Bioeconomy Field Lab, we shall provide evidence-based influence on the Bioeconomy Policy direction in Kenya.

The New Partnership involves our International Project Partners who can leverage the Collaboration with MPESA Foundation to advance the Bioeconomy Field Lab into an Industrial Park and a Centre of Excellence for Bioeconomy Innovations. The Bio-WIN Project partners with the County Government of Kilifi, the Bioeconomy Coalition of Africa, Africa BioEconomy University, European Bioeconomy University, World Bioeconomy Association, Biomass Research, Africa Bioenergy Programmes Ltd, and Biogas International

Conclusions and Strategy

The development of the Centre shall be done in Phases, with Priority to be given to the Signage (billboard), Repairs, Construction of a large-scale biodigester, and equipping the Museum of the Future with Digital Tools. The Lab and Workshop spaces will be integrated into the TVET Complex proposed. The Upgrades envisaged are estimated to boost Biogas production threefold, to move the output to approximately 40% of all power needed for cooking and heating in the University Kitchen. Bio-WIN will also leverage the Greening Kilifi Initiative to partner with the County Government and other stakeholders in the Green Transition Space in a long-term Collaboration to Champion Bioeconomy Innovations for sustainable development and Climate Resilience across the County of Kilifi, the Country of Kenya, Africa at large, and the Globe. Contributing to the Sustainable Development of Goals of the United Nations.