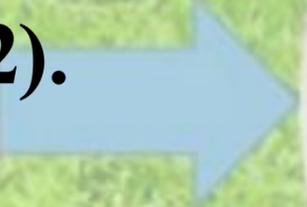


**Integrated System for Unlocking Valourization
Benefits of Agricultural and Hospitality Industry's
Green and Food Waste Streams**

BACKGROUND

- **Waste (organic and inorganic) has consequences on global economy, waste generation and disposal exacerbate climate change, biodiversity loss and pollution (UNEP, 2022).**
- **Globally, about 1.05 billion tonnes of food waste is generated approximately 132 kg per capita (UNEP, 2022).**
- **In Nigeria, about 37.9 million tonnes of food is wasted yearly estimated as 189 kg of food per capita, and 40 % of total food produced which is enough to feed 40 million people (Casson et al., 2020, UNEP, 2021, Haruna et al., 2023).**
- **FAO (2021) reported that yearly post-harvest food losses amount to \$9 billion and approximately a quarter of yearly budget for Nigeria.**



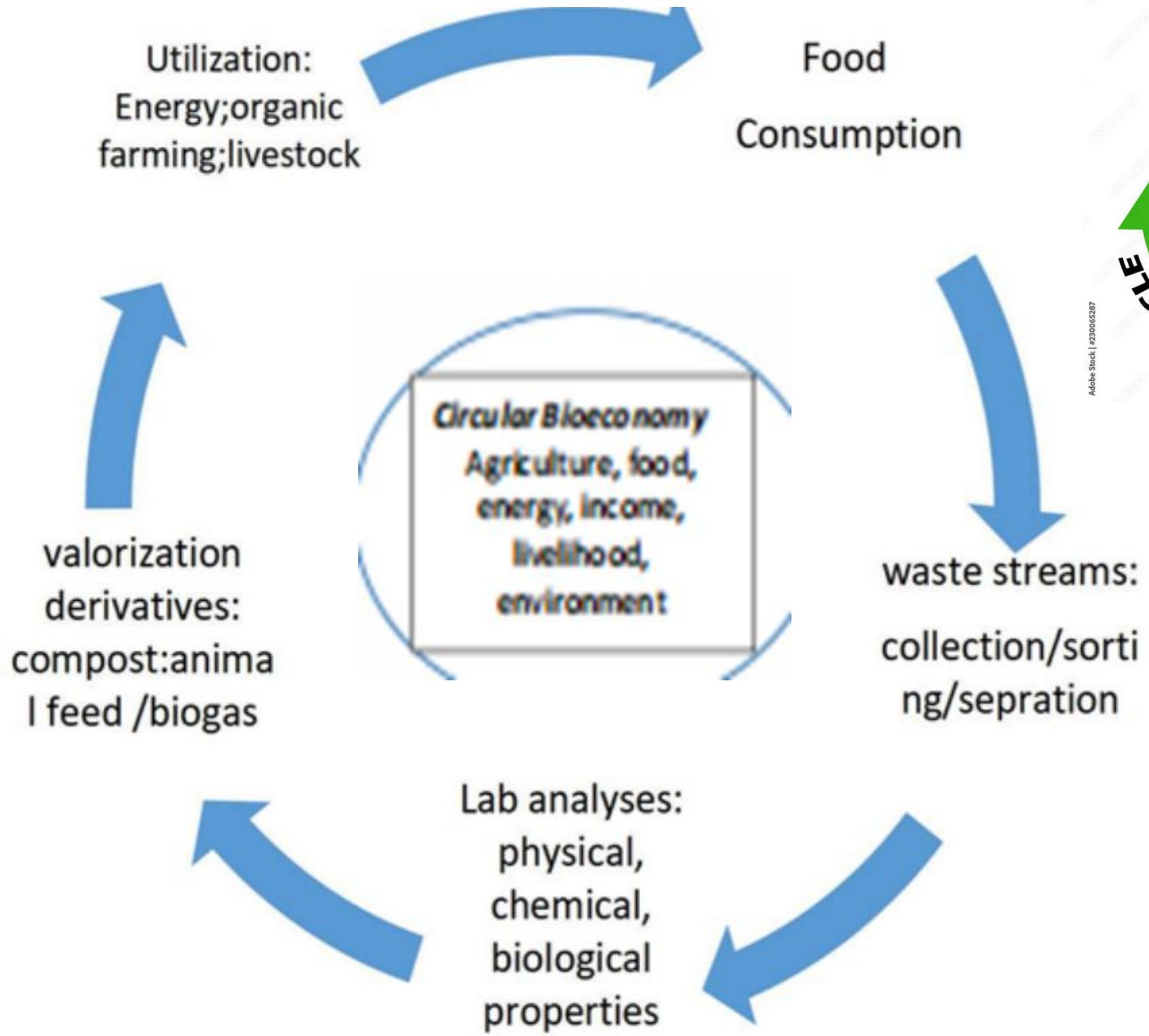
BACKGROUND

- **The National Bureau of Statistics (NBS) reported that over 82 million Nigerians live on less than \$1 daily base on the country's ranking in UN food wastage index.**
 - **Nigeria ranks among the top countries globally for waste generation (Kolawole et al., 2024).**
 - **Increasing population growth and associated spikes in demand for food and agricultural products have resulted in significant increases in waste generation (Kolawole et al., 2024).**
 - **Sustainable Development Goal on food and environment discourage waste generation, and**
 - **encourages development of strategies for material value addition, sustainable production, processes and consumption.**
- 

BACKGROUND

- Several small and medium-sized enterprises (SMEs) in Nigeria engage in the development of backyard plastic made biodigester to convert municipal wastes into usable products for various applications (industry, health and agriculture).
- However, these SMEs could not scale-up due to low capacity for process plants
 - Thus, it is imperative to develop biodigester and pyrolysis systems for environment-friendly digestion and conversion of biowastes to added-value products using locally available materials.





3R's of Recycling

Detailed Design of the Process Equipment

Finite Element modeling and evaluation of the designed and integrated process equipment: Models of the developed concepts of each of the process equipment will be developed in finite element analysis (FEA) software (ANSYS) and exhaustively simulated to determine their functionality and reliability.

The features of the FEA model will be assembled using the values of the design parameters determined during detailed design and the actual properties required of the selected materials. Appropriate boundary conditions will be applied with respect to the function the equipment or its components is/are to perform to integrate the various equipment into a biodigester.

STATEMENT OF THE PROBLEM

- **Worldwide, waste generation and disposal has attracted increasing attention due to its tremendous environmental, economic, and social significance.**
- **Increased generation of solid wastes is expected with population growth especially food and green plant wastes from hot spots such as agriculture, homes and hospitality industries. (Baban, 2019, Kolawole et al., 2024).**
- **These waste streams have serious implications for sustainability of agricultural and city landscapes and environment health. Out of the total amount of wastes generated, less than 12% being recycled (UNEP, 2022).**
- **It is reported that food loss and waste generate 8-10 % of annual global greenhouse gas (GHG) emissions in addition to biodiversity loss**

STATEMENT OF PROBLEM

- **About one-third of all food produced for human consumption is wasted.**
- **This calls for innovative solutions to minimize waste generation and harness its potential as a resource (added-value products) and attain circular economy growth**

Project is designed to promote capacity for harnessing resource re-use potentials of biowastes via valorization as envisioned in developmental agenda of Governments and NGOs such as Nigerian National Action Plan, AU 2030, UN Sustainable Development Goals (SDGs) No.: 2 and & 12 (Zero Hunger & Sustainable Consumption and Production).

AIM

The aim of this project is to deploy environment-friendly valorization technologies to transform biowastes to value-added products and materials for application in agriculture (organic vegetable and broiler production).

OBJECTIVES

Specific objectives are to:

- provide baseline data on food and green plant waste streams from agricultural, home and hospitality industry via preliminary survey and Waste Auditing;**
- conduct laboratory analyses (physical, microbiological and chemical of waste streams and valorization derivatives (compost, alternative livestock feed));**
- design and fabricate equipment for waste valorization (Biodigester: biogas/ liquid fertilizer), pyrolysis (biochar);**
- evaluate valorization derivatives for vegetable production and livestock feed ingredient (poultry: layers/broilers);**
- evaluate the socio-economic and environment impacts of the valorization and application activities;**
- build capacity and training for smallholders (women and youth, postgraduate students),**
- train Masters and PhD candidates**

Benefits

- provision of data on biowaste (green plant and food waste from farm, home and hospitality industry) generation and disposal options
- enhanced technical know-how via development of environment-friendly technologies for biowaste valorization to added-value products
- enhanced food security, nutrition, livelihood, wealth and environment conservation benefits
- reduced cost of production and increase availability of agro-inputs (biogas, biochar, digestate, liquid fertilizer and poultry feed/ingredient, and
- build capacity through training (farmers and students)
- **Technology transfer & Patent** (potential)



Research Methodology

Project Activities

Major activities are designed to achieve the set objectives of Project (depicted in Figure 1).

The study will commence review of related literature, and resultant identification of valorization steps (processes) of biowaste streams from agricultural and hospitality industry's green and food waste streams

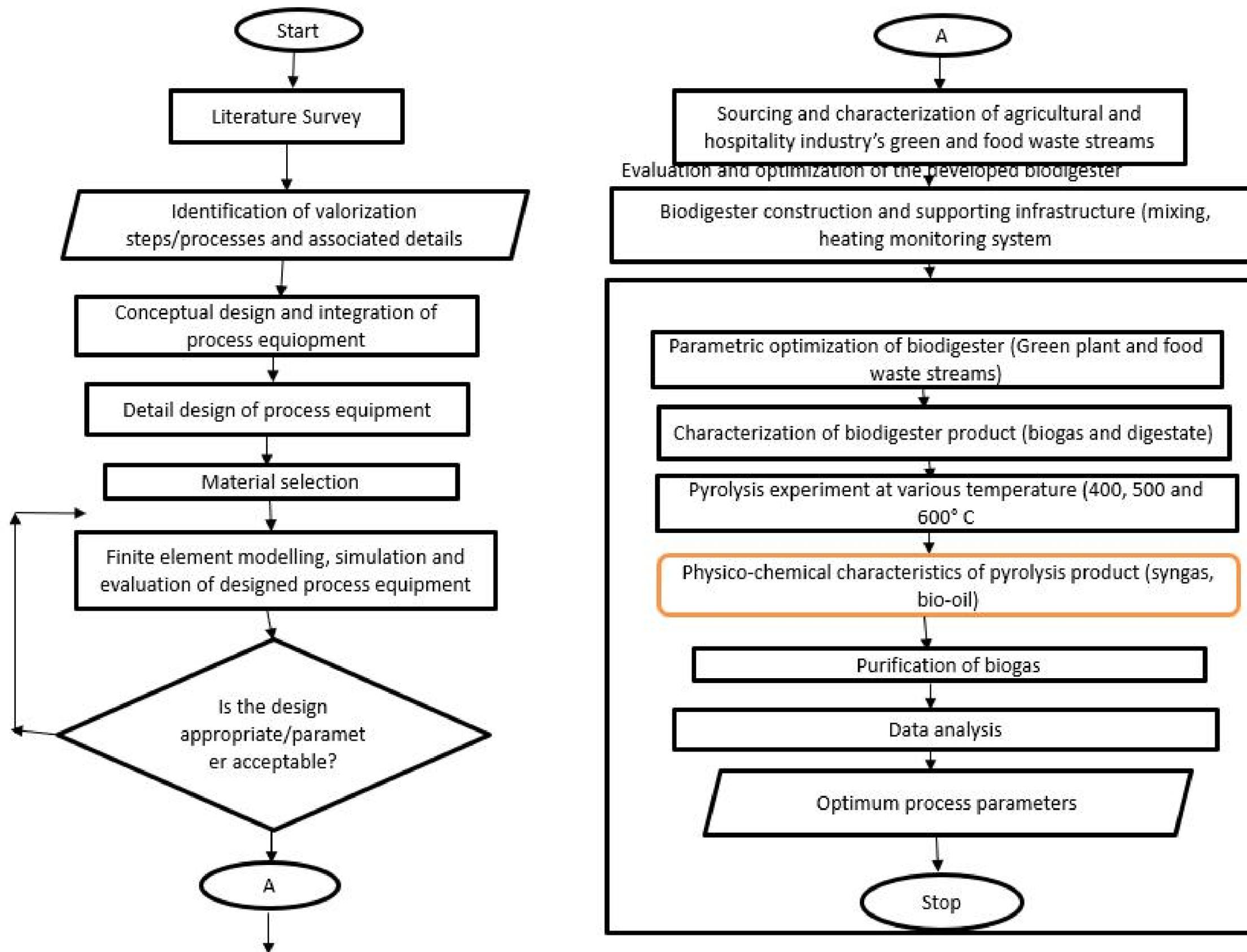


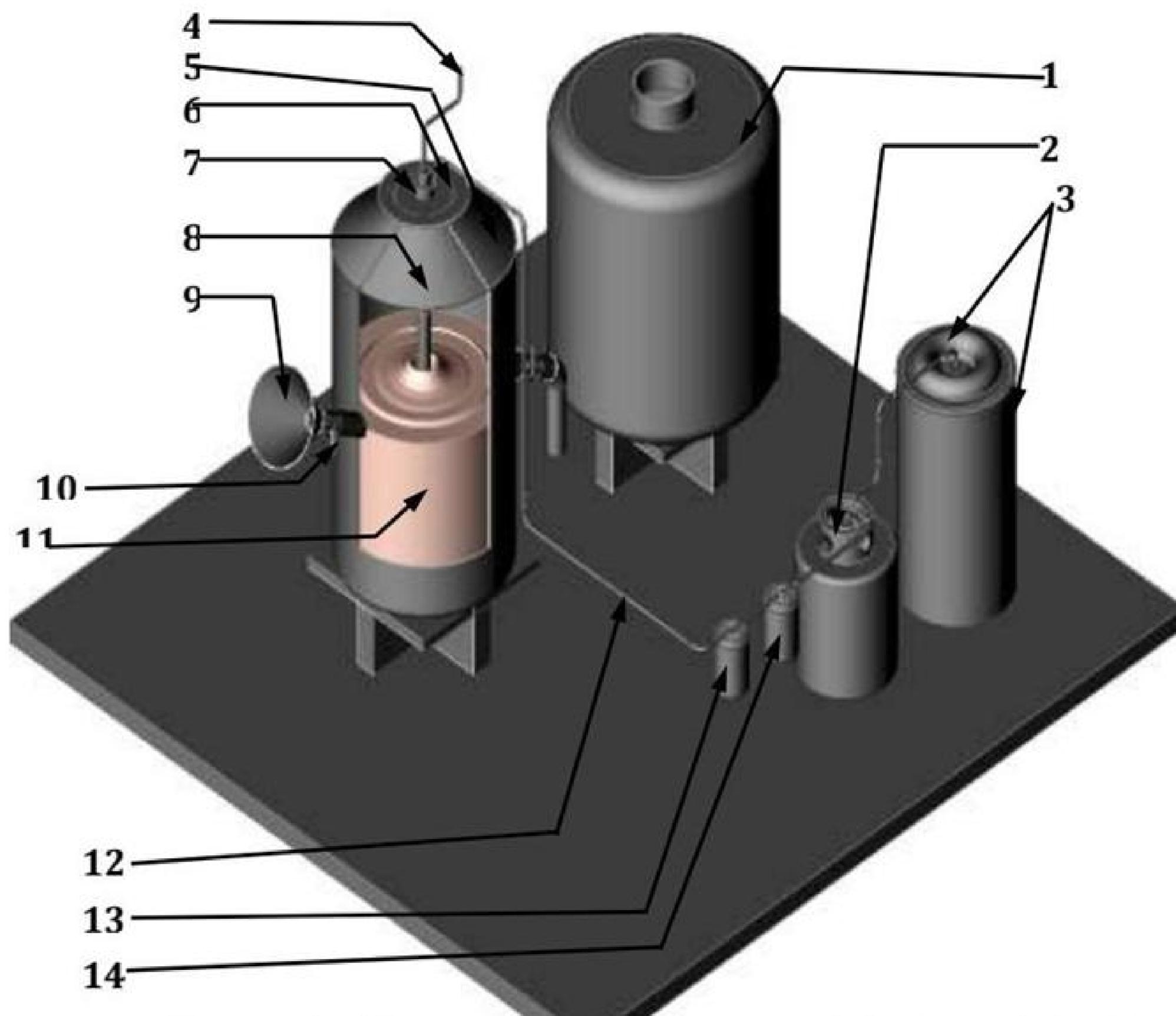
Figure 1: Flow diagram for the development of the hybridized biodigester and and pyrolysis systems

Conceptual Design and Integration of Process Equipment

Four digestion components are identified (i.e., digestion drum, inlet for feeding the agricultural and food waste, outlet for digestion slurry, gas collection and storage system) and the processes (Fig 2)

The information will be depolyed to develop the conceptual design of the process equipment and supporting infrastructures

Fig 3 shown the anaerobic digestion and pyrolysis.



Legend key

1. PVC water tank
2. Gas cylinder
3. Moisture trap container
4. Stirrer
5. Gas delivery pipe
6. Control valve
7. Pressure guage
8. Digester gas container
9. Inlet chamber
10. Control valve
11. Slurry
12. Rubber holes
13. Potassium hydroxide solution
14. Potassium permanganate solution

Figure 2: 3D view of the conceptual design of the biodigester

Activities Cont'd

Applications of valourization derivatives (value-added products and materials) Animal trial: Validation of the formulated feeds from biowastes for poultry production.

- i. Best growth-supporting feeds derived from biowastes for poultry compared to commercial feeds.
- ii. Nutritional quality evaluation of feed and poultry product

Valourization product evaluation for organic vegetable production:

- i) Organic fertilizers from valourized¹⁶ biowastes will be evaluated for vegetable production on the field and greenhouse .
- ii. Best growth-supporting rates and types of organic fertilizers will be evaluated compared with inorganic fertilizers.
- iii. Soil properties and nutritional qualities of vegetables

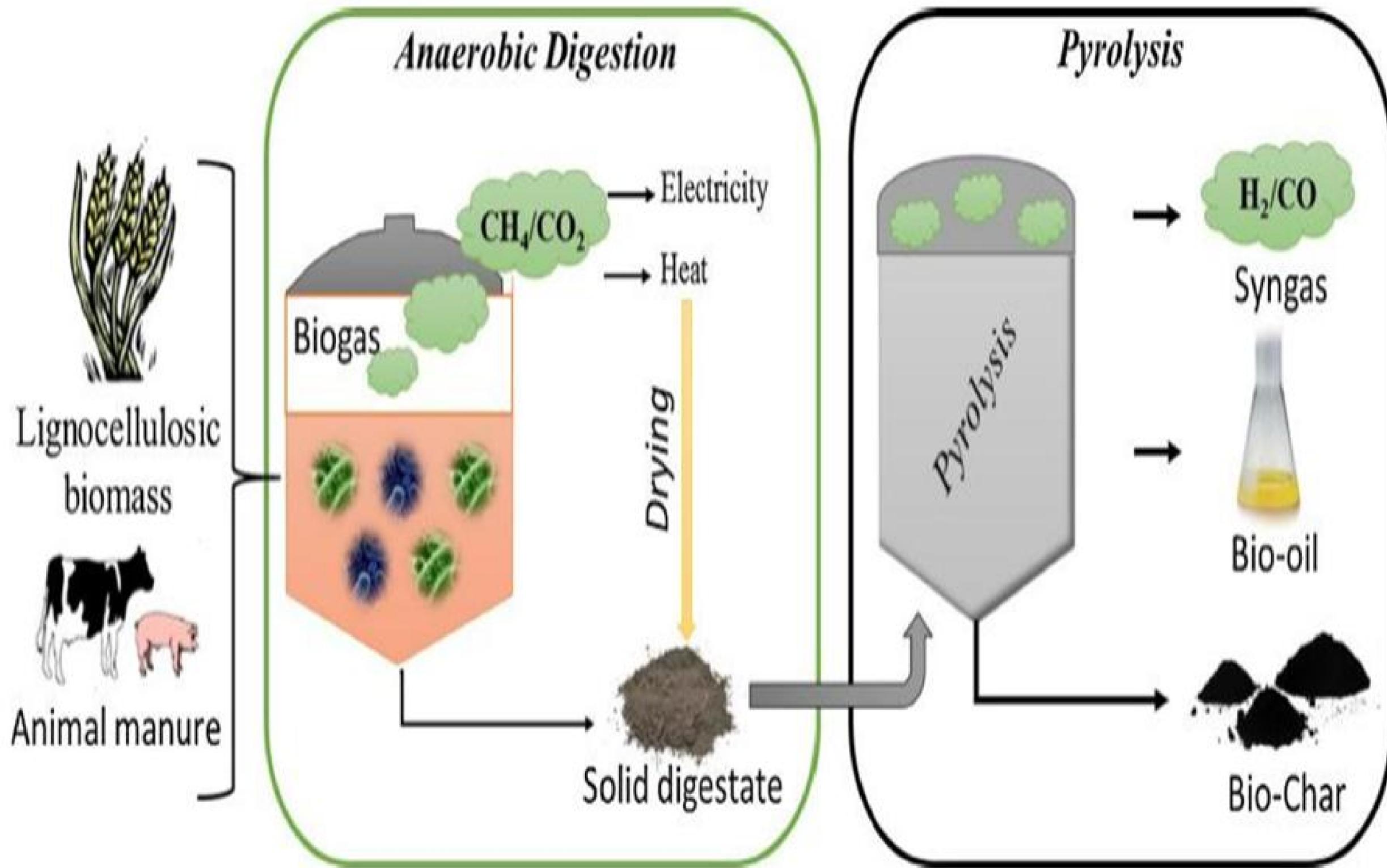


Figure 3: Conceptual framework and diagram of the material transformations and consequent energy conversions of organic feedstock through the sequence “Anaerobic digestion” and “Pyrolysis”

Pyrolysis Experimental Procedure

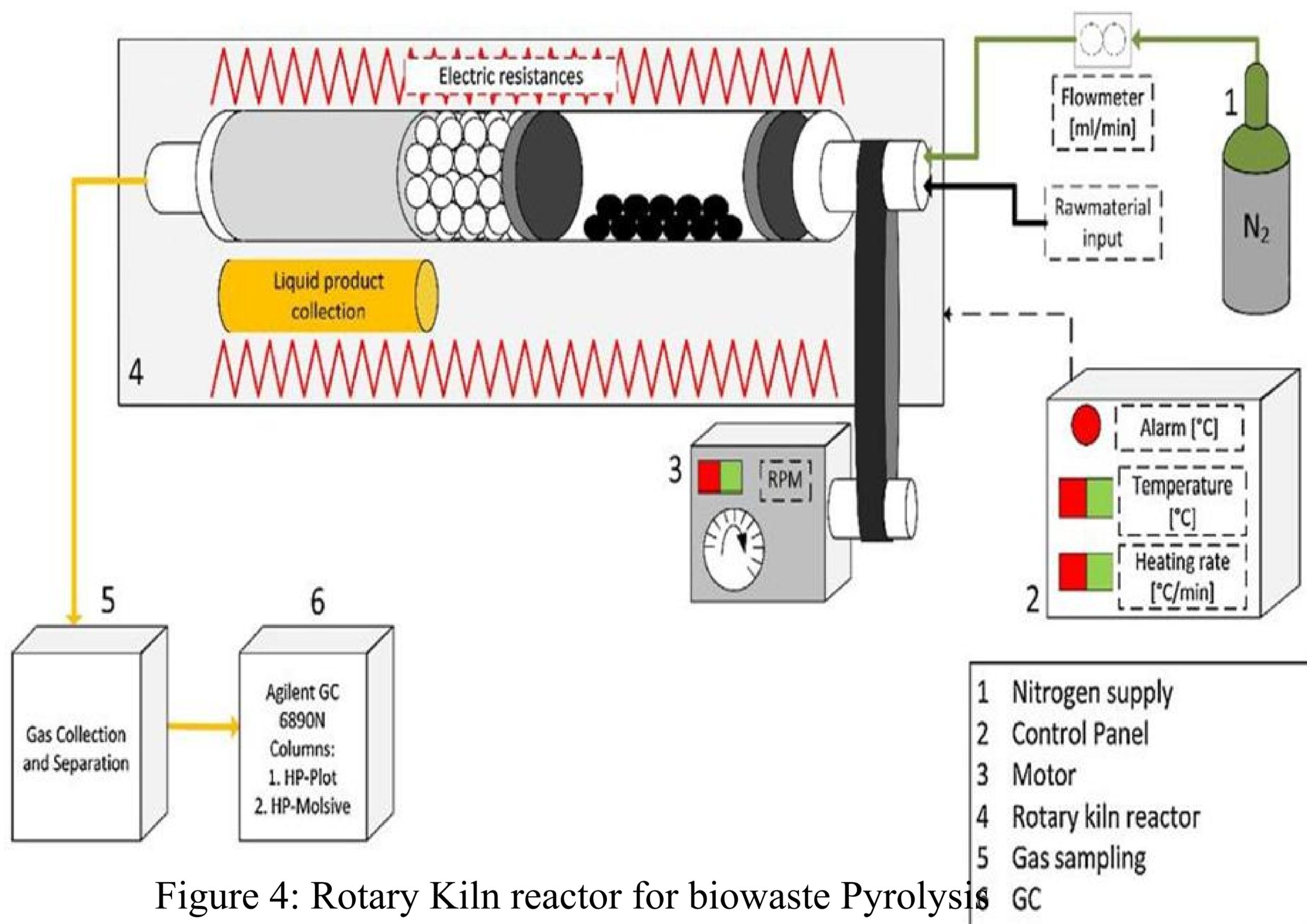
Pyrolysis of biowaste streams will be performed at the Department of Chemical Engineering, FUT, Akure, Nigeria.

Existing pyrolyzer will be modified with the necessary accessories to suit the need of the experiment.

A quartz rotary kiln reactor will be used to carry out pyrolysis experiments.

The process set up will include a quartz tube ($L = 0.8$ m, O.D. = 0.03 m), a furnace NABERTHERM DRSR-A-70/500/11 and a Vexta GF52G100 Oriental Motor CO LTD mounted with a VEXTA DC Motor Driver (Model BFD30C).

These components will be assembled as shown in Figure 4.



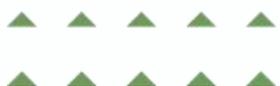
Detailed Design of the Process Equipment

The factors that influence the designed concept developed for the process equipment and/or units will be identified and considered in the detailed design analysis

Important parameters to ensure adequacy of design and construction of process equipment will be determined and integrated.

Material Selection:

The function the material is to perform, the properties of the material, the shape to be formed with the materials, the manufacturing processes required to form the material, the availability of the material, and the cost are the factors that will be considered in this phase of the Project.



Parameter Evaluation Used in the Design Calculation of Biodigester

The standard reference for loading of biodigester are as follows:

Amount of total solid (TS) : $TS = 85\%$ of the slurry

Volumetric capacity V_d : $V_d = \pi r^2 h$

Amount of volatile solid (VS) in the slurry: $VS = 0.8TS$

Cylindrical volume digester: $C_y = \pi r^2 h$

Substrate input S_d : $S_d = B + w(m^3/d)$

Conical volume digester: $V_{CD} = \frac{1}{3}(\pi r^2 h)$

Hydraulic retention time (HRT)

Daily gas production, G : $G = x \times y \times z$

Specific gas production G_p : $G_p = \frac{G}{V_d} \left(\frac{m^2}{m^3} \right)$

Digester Loading L_d : $L_d = \frac{Ts}{V_d} \left(\frac{kg}{m^3 d} \right)$

Volume of gas holder v_g : Gasholder capacity $C = V_g/G$

Biogas yield: $G_y = \frac{V_d}{F_s}$

Other Activities

Preliminary survey and biowaste auditing

Survey of biowaste generation and management options from agricultural, home and hospitality industry

Biowaste collection, sorting, transport and storage

Biowaste valorization and added-value product characterization:

Pre- and post-valorization characterization of wastes and added value products for biochemical properties (nutrient profile²² and pathogen load) in FUTA laboratories

Production of added-value derivatives from biowastes

Biowastes will be valorized to produce biogas, digestate, liquid organic fertilizer, biochar, livestock feed/ingredients using Biodigester, Pyrolysis, and dryer

Project activities Cont'd

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Socioeconomic and environmental impacts of project:

- i. Cost-benefit analysis of biowaste valorization : Profitability and feasibility of biowaste-derived feed for poultry and **digestate for organic** vegetable production will be evaluated
- ii. Environmental impacts of project via Life Cycle Assessment (LCA): The aim is to indicate capacity of biowaste valorization to yield environmental credits compared with other disposal options (incineration and landfill, burning, disposal on soil and water bodies).

Process equipment “Anaerobic digestion” and “Pyrolysis

Capacity Building (Training), Dissemination and Report Writing

Activity will offer opportunity to bring project findings to the attention of the stakeholders and promote adoption of biowaste valorization technology and application

Dissemination of findings: Via Seminars/Workshops/stakeholder meeting 23

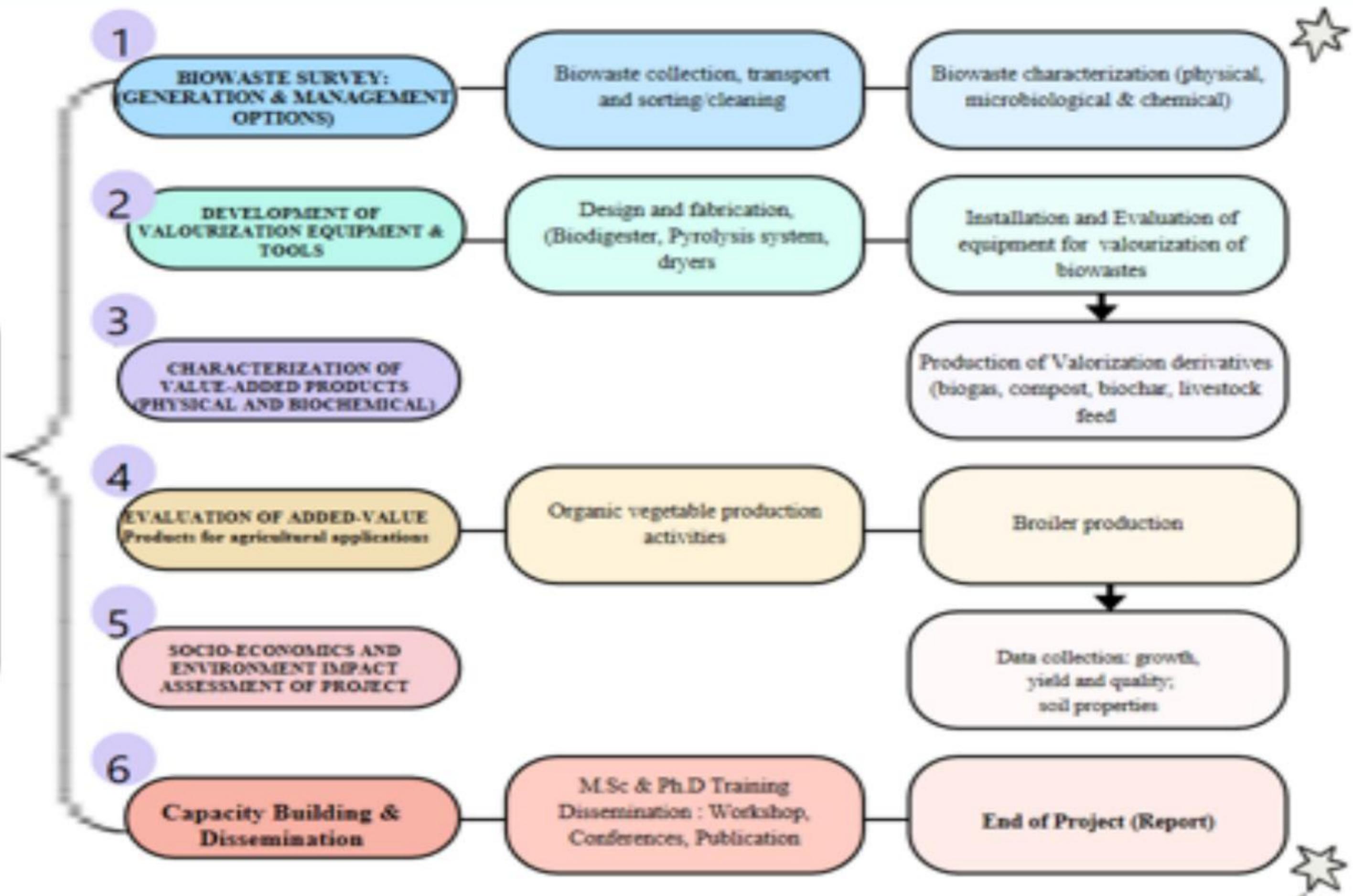
The activity will offer opportunity to display products and findings from the project

Journal publications Findings will be published in reputable journals:

Capacity building and training needs of students (Masters and PhD These) and stakeholders

End of project report will be written and submitted to TETFUND.

Figure 7: FLOW DIAGRAM OF PROJECT ACTIVITIES



**THANK YOU
FOR LISTENING**

