Circular business models for small-scale bio-based technologies in rural Africa: Co-creation and validation with local stakeholders

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What did we want to achieve

- Analyze the **Bio4Africa value chains** developed by the bio-based solutions introduced in each case
- Co-design inclusive and sustainable **value propositions** as well as bio-based **business models**
- **Improve and fine-tune** the business models based on evidence from testing in real life conditions

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Our methodology

- Market segmentation and analysis conducted by Q-PLAN was our starting point.
- Task 5.1 literature was revievewed and provided rationale for conducting the value propostion workshops across the 4 countries and eventually bussiness model development.
- The stakeholders for value proposition were diverse and at different levels of value chain i.e producers , input suppliers ,traders, customers , farmers.
- A one day workshop was used to codesign a value proposition workshop in the four countries through structured design and participatory process
- The value propostion canvass guided the stakeholders whereby elements of product features, pain creators , pain relievers were discussed.
- The participants developed a profile of the different bio based products specifying the gain creators , pain relievers and products features

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Our approach

Implementation

✓ 4 **Market Scenario** workshops

Country	BIO4AFRICA representatives	Date	Participants
Cote D' Ivoire	INP-HB	7/3/2022	30
Ghana	iHub & SAVANET	3/3/2022	27
Senegal	UASZ	2/3/2022	30
Uganda	AFAAS & KRC	18/2/2022	25

✓ 4 **Value Proposition** workshops

Country	BIO4AFRICA representatives	Date	Participants
Cote D' Ivoire	INP-HB	09/8/2022	15
Ghana	iHub & SAVANET	30/8/2022	17
Senegal	UASZ	12/8/2022	20
Uganda	KRC & AFFAS	29/9/2022	11

Value Proposition Workshop: Ghana

Value Proposition Workshop: Senegal

Value Proposition Workshop: Cote d'Ivoire

Value Proposition Workshop: Uganda

✓ 28 **Interviews** with experts conducted

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The Value Proposition Canvas

Step 1: Co-design value proposition

1) Biochar for Soil Amendment
2) Biochar for Bio-fuel/briquettes
3) Biochar for Water Filtration
4) Animal Feeds &Protein Fish Sup.
5) Fish Feed Pellets
6) Bioplastics & Biocomposites

Step 2: Co-design business models

Designed for:	Designed by:	Date:	Version:

Value Proposition Canvas

Gain Creators

Gains

Product

Benefits List value proposition(s)/ products & services offered

Experience Describe how products and services create customer gains.

Features /Functional attributes

Pain Relievers: Describe how your products & services alleviate customer pains.

Customer

Wants Describe what customers get done in their work and lives

Fears Describe bad outcomes, risks and obstacles related to customer jobs

Needs What are the social, economic & environment benefits offered

Jobs: list what the customer need to do in order to access & use products

Pain Creators

Pains

Product /Name

Ideal Customer /List

Substitutes

List

The Triple Layered business model canvas

Step 2: Co-design business models

1) Biochar for Soil Amendment

2) Biochar for Bio-fuel/briquettes

3) Biochar for Water Filtration

4) Animal Feeds &Protein Fish Sup.

5) Fish Feed Pellets

6) Bioplastics & Biocomposites

Sustainable business models

A	**Partners**	**Activities**	**Value Proposition**	**Customer Relationship**	**Customer Segments**
Economic Business Model Canvas		Resources		Channels	
	Costs		Revenues		
B	**Supplies and Out-sourcing**	**Production**	**Functional Value**	**End of Life**	**Use Phase**
Environmental Lifecycle Business Model Canvas		Materials		Distribution	
	Environmental Impacts		Environmental Benefits		
C	**Local Communities**	**Governance**	**Social Value**	**Societal Culture**	**End User**
Social Stakeholder Business Model Canvas		Employees		Scale of Outreach	
	Social Impacts		Social Benefits		

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Results

- ✓ Participatory co-designing process involving key regional stakeholders across value chains.
- ✓ 4 Value Proposition workshops conducted across the testing sites and profiles developed for all bio-based products using Value Proposition Canvas.
- ! **10 Circular & Inclusive Business Models developed using Triple Layered Business Model Canvas (TLBMC) for the bio-based products**

Business Models	
Biochar as a soil amendment product	Press cakes as ruminant feeds
Biochar as a solid biofuel product	Whey as monogastric feeds
Biomass pellets as bio-feeds for livestock	Protein concentrates as feed supplements for livestock, poultry, & fisheries
Biochar as an additive in biogas production	Fish Feed Pellets
Biochar powder as a medium for water filtration	Bioplastics and composites

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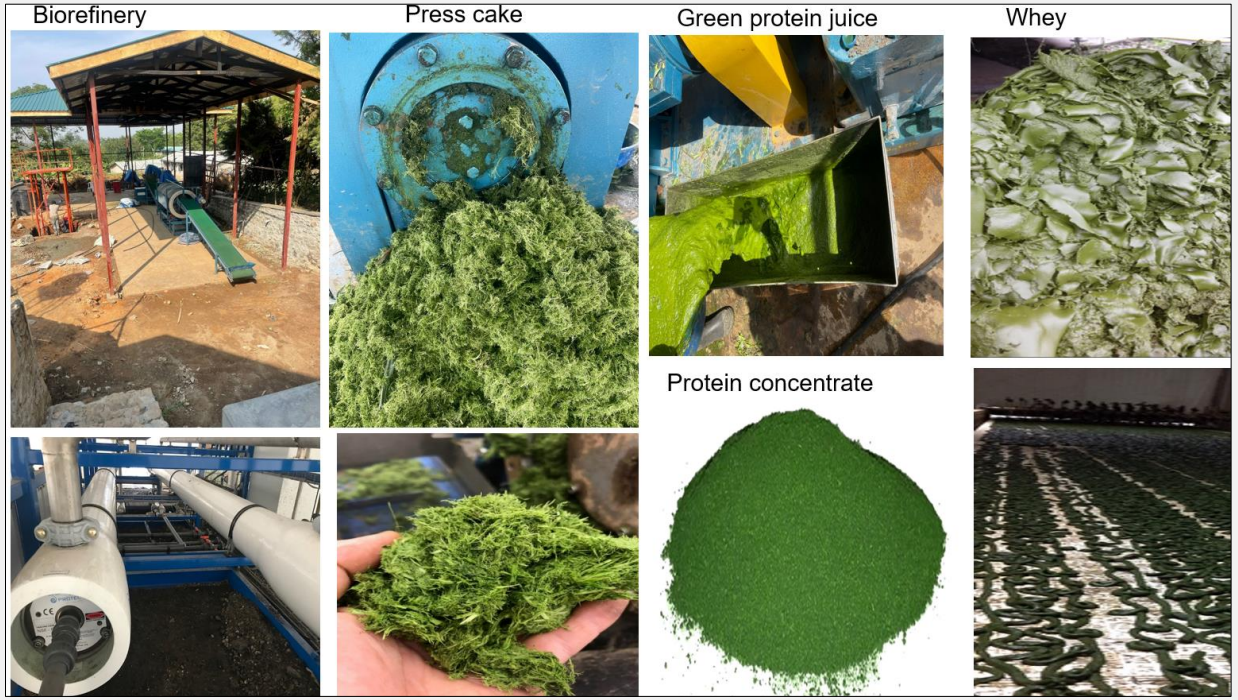
Results

Densification &
Pelletisation Milling

4) Green Biorefinery - Animal Feeds & Protein Fish Feed Sup



5) Densification & Pelletisation Milling for Fish Feed Pellets

6) Densification and Pelletisation Milling for Fish Feed Pellets

Cashew Apple

Molasses

Polyhydroxy-alkanoates (PHAs)

Biocomposites & Application

Bioplastics

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Our methodology for improving Business models

2nd Iteration

- Interviews with **technology experts**
- Online questionnaire survey with **AB members**
- Online questionnaire survey with **DIVAGRI consortium**

4th Iteration

- **Social layer: Questionnaire survey** from local stakeholders in raising awareness events
- **All layers: S-LCA, LCA, LCC** data comparison

1st Iteration

- **Interviews** with participants in the local boot camps (representatives of local companies)

3rd Iteration

- Questionnaire survey from **Pilot's users (farmers etc)** in local stakeholder engagement events

- Formulation of **preliminary hypothesis** for each business model (product/ country)

- BMs and VPs elaboration & assessment for each product & each country
- Basis: a) information available in market and value chain analysis, b) information on sustainable business models archetypes, c) Information on strong points and challenges in circular business models

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Whom did we engage

Number of participants in validation process

1st Iteration	
Participants in Bio4Africa business acceleration bootcamps	20
2nd Iteration	
Small-scale biobased technology experts	15
3rd Iteration	
Local farmers and stakeholders	267

We engage local business stakeholders, receiving business support to engage in bioeconomy ventures to gain their **insights, needs, challenges, and the desirability of implementing our solutions.**

As the pilot and validation activities progress, we engaged with technology experts (within and outside of the consortium) **to validate and improve specific information mainly in the economic layer of our business models.**

To improve our business models based on user feedback, we engage the local farmers and stakeholders who are **familiar with our pilot activities.**

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MVBM approach

Minimum Viable Business Model

" The smallest and simplest version of a business model that can deliver value and meet the basic requirements of a project"

- **Business models requiring the minimum number of technologies**
- **Prioritization of value propositions**
- **Focus on critical resources and activities**
- **Identification of essential customer segments**
- **Definition of the most minor organization that could implement each business model**

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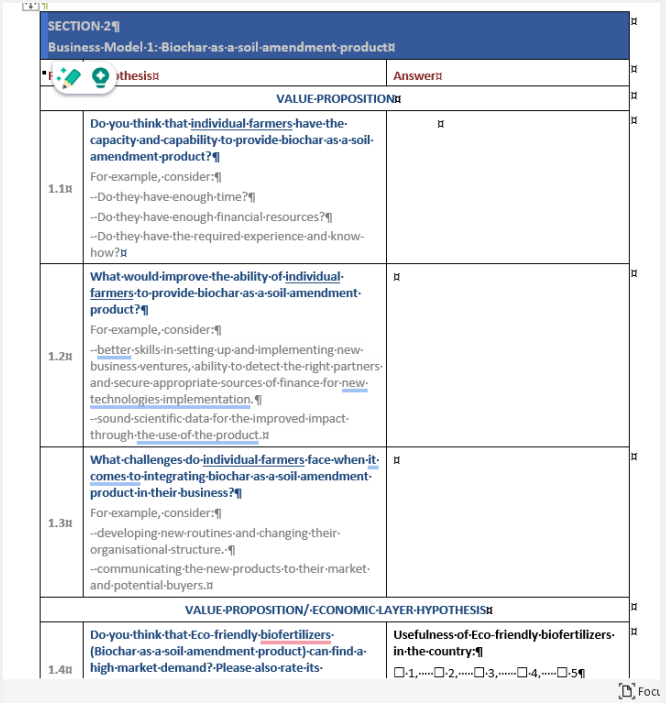
1st iteration- What did we ask?

Aim: a) Develop and validate our hypotheses, b) Fine-tune value propositions

Hypothesis	Hypothesis questions
1. Biochar as a soil amendment product	
Eco-friendly biofertilizers (Biochar as a soil amendment product) can find a strong demand in the market	Usefulness of ecological biofertilisers in the cou
	Usefulness of ecological biofertilizers for person
Selling Biochar as a soil amendment product bring enough income to a farmer and/or increase the availability of jobs	Suitable for today's smallholder farmers:
	Suitable for the farmers association in the futur
	Suitable for increasing jobs in the future:
The use of Biochar as a soil amendment product can promote the reduction of greenhouse gas emissions and/or increase the availability of nutrients in crops	Management of greenhouse gas flows:
	Nutrient recycling:
	Soil properties and health:
	Reduction of seasonal pressure on natural resou
Types of stakeholder that would increase the impact of using biochar as a soil amendment product in Senegal	Producers, traders and suppliers
	Local agro-industries
	District Local Governments (DLGs) and Farmer I



SECTION-2¶
Business-Model-1:-Biochar-as-a-soil-amendment-product¤

	thesis¤	Answer¤
	VALUE-PROPOSITION¤	
1.1¤	Do-you-think-that-individual-farmers-have-the-capacity-and-capability-to-provide-biochar-as-a-soil-amendment-product?¶ For-example,-consider:¶ --Do-they-have-enough-time?¶ --Do-they-have-enough-financial-resources?¶ --Do-they-have-the-required-experience-and-know-how?¤	¤
1.2¤	What-would-improve-the-ability-of-individual-farmers-to-provide-biochar-as-a-soil-amendment-product?¶ For-example,-consider:¶ --better-skills-in-setting-up-and-implementing-new-business-ventures,-ability-to-detect-the-right-partners-and-secure-appropriate-sources-of-finance-for-new-technologies-implementation.¶ --sound-scientific-data-for-the-improved-impact-through-the-use-of-the-product.¤	¤
1.3¤	What-challenges-do-individual-farmers-face-when-it-comes-to-integrating-biochar-as-a-soil-amendment-product-in-their-business?¶ For-example,-consider:¶ --developing-new-routines-and-changing-their-organisational-structure.-¶ --communicating-the-new-products-to-their-market-and-potential-buyers.¤	¤
	VALUE-PROPOSITION/-ECONOMIC-LAYER-HYPOTHESIS¤	
1.4¤	Do-you-think-that-Eco-friendly-biofertilizers-(Biochar-as-a-soil-amendment-product)-can-find-a-high-market-demand?-Please-also-rate-its-	Usefulness-of-Eco-friendly-biofertilizers-in-the-country:¶ □-1,-----□-2,-----□-3,-----□-4,-----□-5¶

Country	Responsible partners	Dates	Answers	Business models validated
Cote d'Ivoire	INP-HB	25-29/5/2023	5	BM1, BM3, BM5, BM10
Ghana	iHub, Savanet	9/5/2023	5	BM1, BM6, BM7, BM8, BM9
Senegal	UASZ	30/3/2023	5	BM1, BM2, BM3, BM4, BM10
Uganda	AFAAS ,KRC	30/3/2023	5	BM1, BM3, BM 6, BM7, BM8

- ❑ **Hypothesis accepted when average rating of agreement > 3**
- ❑ **Open questions about MVBM estimation**

- ✓ **All hypotheses have been accepted**
- ✓ **Value propositions have been improved**

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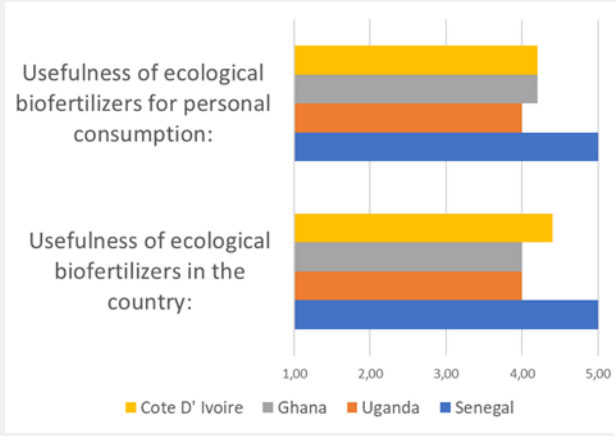
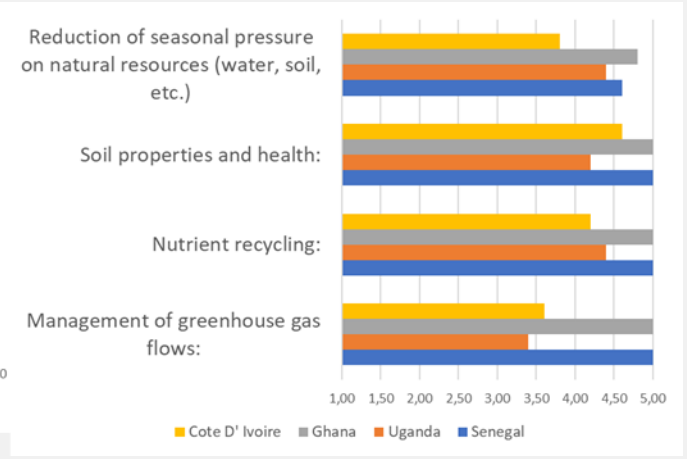
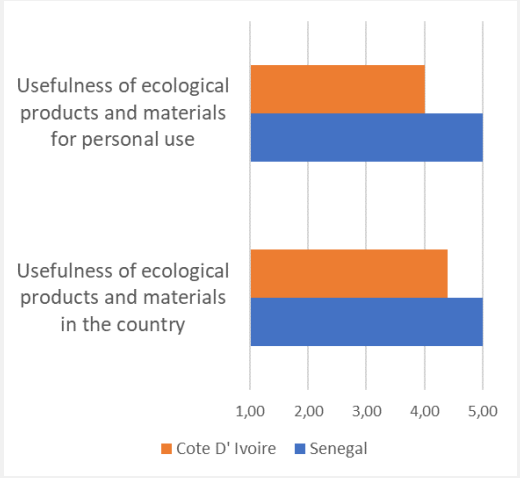
1st Iteration- Answers

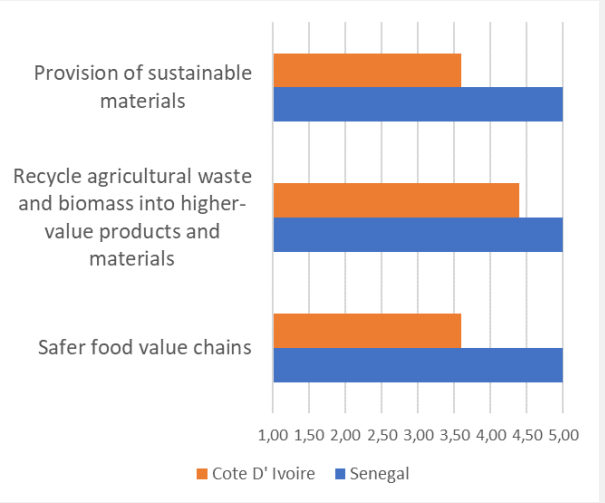
Accepted hypotheses of Economic and Environmental layer of Biochar as a soil amendment product



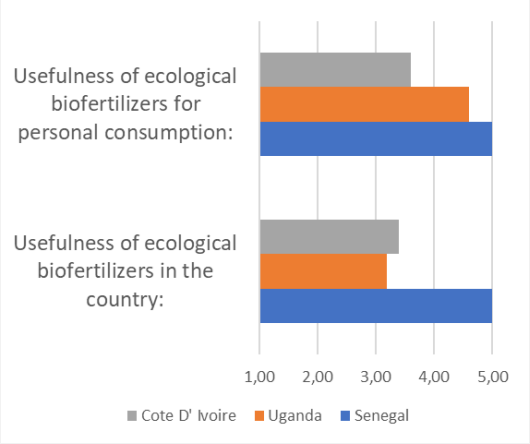


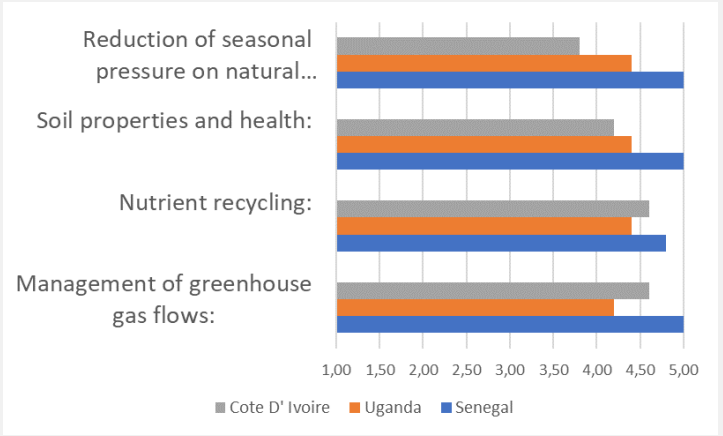
Accepted hypotheses of Economic and Environmental layer of Bioplastics and composites



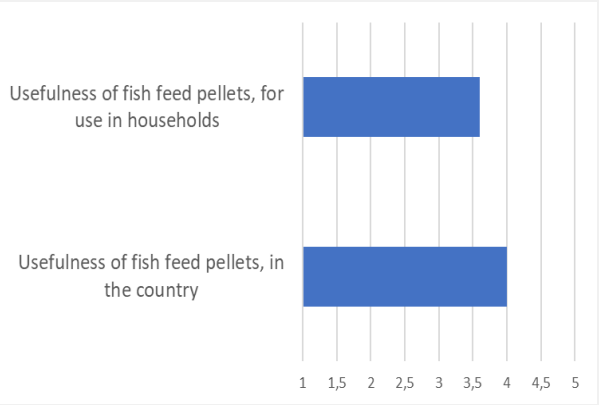


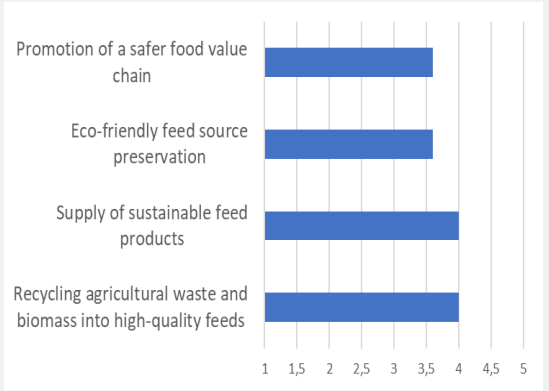
Accepted hypotheses of Economic and Environmental layer of Biomass pellets as bio-feeds for livestock





Accepted hypotheses of Economic and Environmental layer of Fish Feed pellets





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2nd iteration- What and whom did we ask?

Aim:

a) Collect feedback from technical experts on small-scale bio-based solutions.

b) Refine building blocks of the economic layer and Value propositions and key stakeholders of social and environmental layers

- ☑ **Pool of questions per building block**
- ☑ **Valuable qualitative feedback**
- ☑ **Directly on BM canvases**

A/A	Interviewee	Dates	Business models validated
1	**CIRAD**	17/7/2023	BM4, BM5, BM9
2	**CIRAD**	19/9/2023	BM1.A, BM2.A,
3	**RAGT**	10/10/2023	BM3, BM9
4	**INP-HB**	2/11/2023	BM1.A, BM3, BM10
5	**CIRAD**	1/12/2023	BM10
6	**SAVANET**	4/12/2023	BM6,7,8, BM9, BM1.A
7	**MTU**	24/12/2023	BM11
8	**INP-HB**	5/1/2024	BM5
9	**UASZ**	18/1/2024	BM2.A, BM4
10	**GRASSA**	15/3/2024	BM6,7, 8
11	**KRC**	5/4/2024	BM6, 7, 8, BM1.B
12	**Expert #1 (technology provider)**	19/9/2023	BM1.A, BM2.A, BM4, BM5
13	**Expert #2 (AB member)**	8/1/2024	BM1.A, BM3, BM6,7,8 , BM5, BM10
14	**Expert #3 (DIVAGRI)**	6/3/2024	BM1.A, BM3, BM6,7,8 , BM5, BM10
15	**Expert #4 (DIVAGRI)**	25/4/2024	BM1.A

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3rd iteration- Whom did we ask?

Aim: Collect feedback from possible end users of Bio4Africa technology.

✓ The survey encompassed:

Farmers, Farmers' Associations, Women's Associations, Agribusiness Advisors/Consultants, Technology Providers, Commercial Products Distributors, and Policymakers/Public Institutions.

a) Contacts with local stakeholders

Country	Responsible partner	Date	Responses	Business models validated
Cote d'Ivoire	INP-HB	April 2024	81	BM1,BM3,BM5
Ghana	SAVANET	March 2024	40	BM1,BM9
Senegal	UASZ	March 2024	51	BM1,BM2,BM4
Uganda	AFAAS & KRC	March 2024	40	BM6,7,8

b) Raising awareness campaigns

Country	Responsible partner	Date of raising awareness event	Responses	Business models validated
Ghana	SAVANET	January 31st, 2024	32	BM1, BM6,7,8 , BM9
Uganda	AFAAS	January 25th, 2024	23	BM6,7,8

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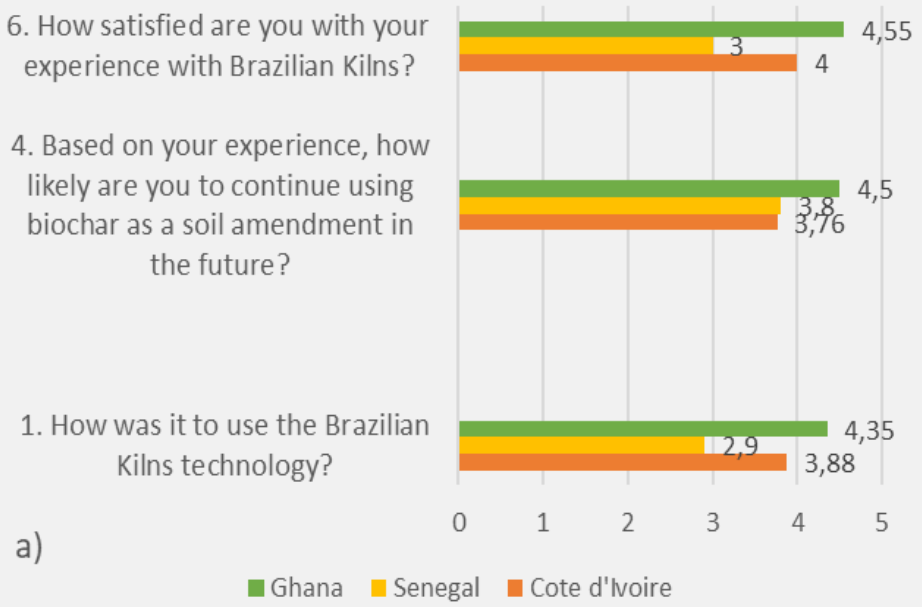
3rd iteration- What did we ask?

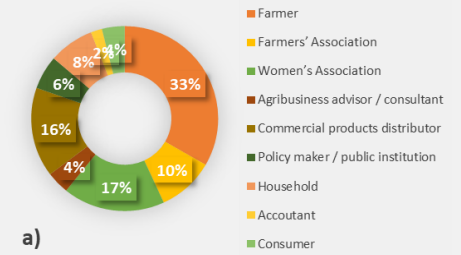
3rd iteration

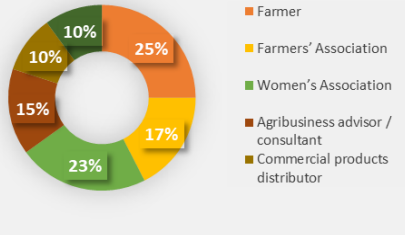
Short questionnaires for farmers, pastoralists, value chain actors

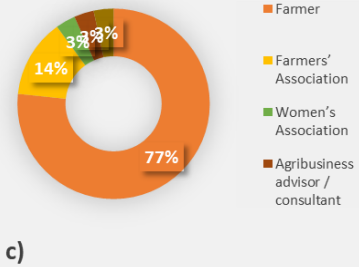
- ☑ User experience
- ☑ Likelihood to use the products
- ☑ Economic impact
- ☑ Potential owners

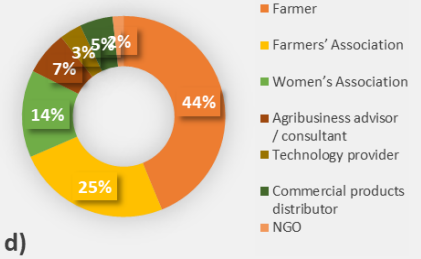
Brazilian kilns utilisation in Ghana, Senegal and Cote D' Ivoire











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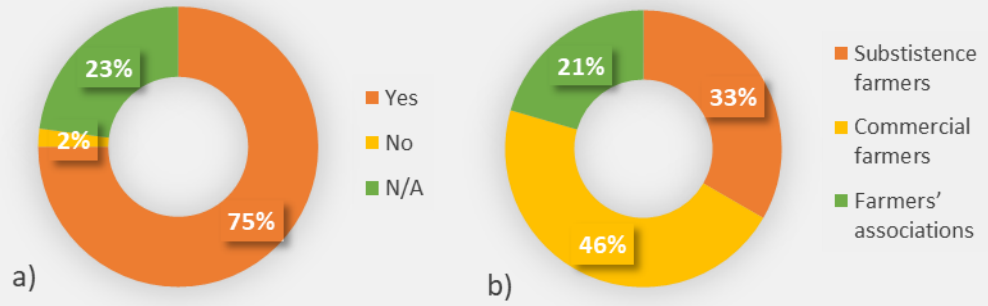
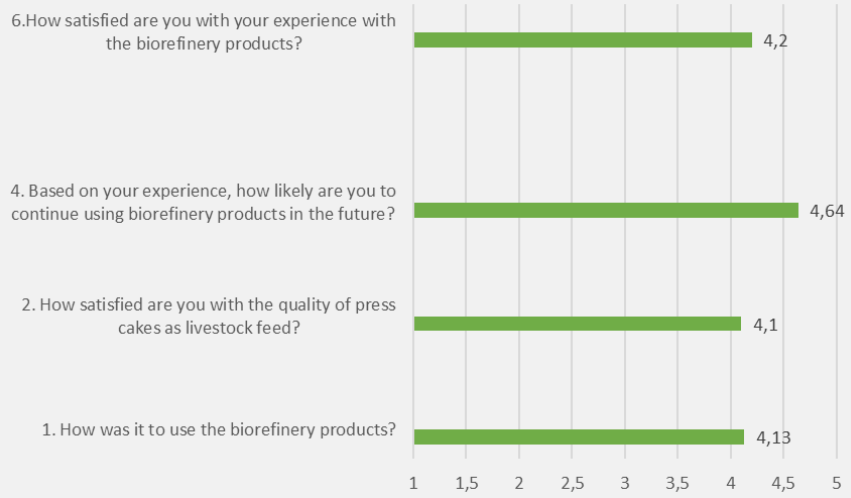
3rd iteration: Answers

3rd iteration

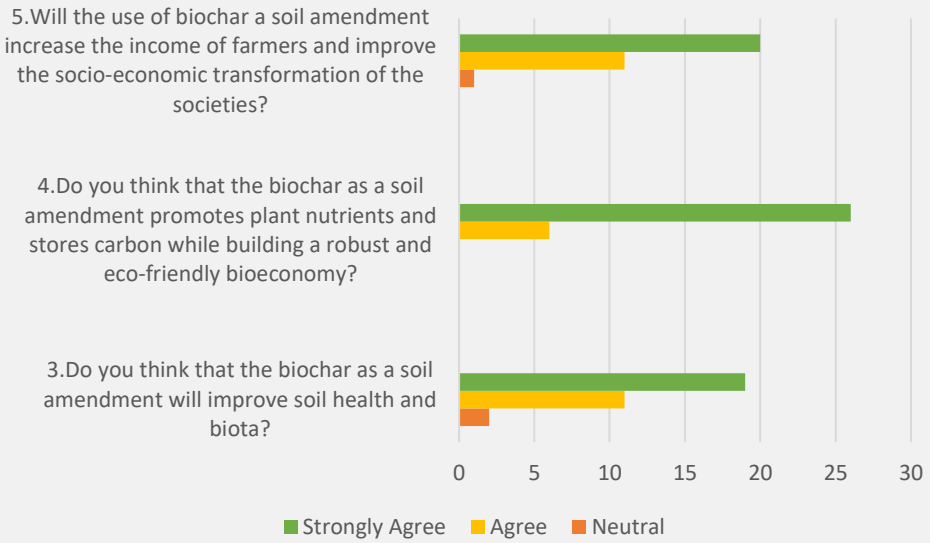
a) Economic Impact and b) Potential Owners of Densification Technology



a) Economic Impact and b) Potential Owners of Small-scale biorefinery in Uganda



Pyrolysis Technology: Perceived benefits



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3rd iteration: Conclusions

- All value propositions have been validated through hypothesis approach and made more specific
- Basic building blocks of the economic layer have been refined according to experience from pilots

Value Propositions of Business Models

BM1: Biochar as a soil amendment product	BM2: Biochar as a solid biofuel product	BM3: Biomass pellets as bio-feeds for livestock	BM4: Biochar as an additive in biogas production	BM5: Biochar powder as a medium for water filtration	BM6-7-8: Small-scale Green biorefinery	BM9: Fish Feed Pellets	BM10: Bioplastics and composites
•Enhanced soil health and biota, especially for sandy soil •Cheap, using agricultural by-products (no raw materials cost)-farmers •Simple to use for farmers Simple infrastructure necessary (soil-based or platform from concrete a cover for rain) •No qualified personnel required • Scalable operation (1- 4 kilns) •Suitable technology for scale-up	•Eco-friendly bio-fuel products (biochar and charcoal) •High-quality (dry and clean) energy products •Recycling wastes from agriculture & forestry •Decarbonization and carbon sequestration for a more resilient bioeconomy	•Biomass pellets as bio-feeds for animal feed •Easy to store and use throughout the year with economic and environmental benefits	•Increase productivity of biogas •Provision of clean energy •Reduced costs of energy use •Easy access to energy for citizens •Saves forests against deforestation for biomass fuels	•Purified safe water for human and livestock consumption	•Improved silage for ruminants with better digestibility and easier to store and transport •Supply of feeds with essential amino acids (protein concentrate) •Safe feed products adaptable to a wide range of livestock and crops (ruminants, pigs, chicken) •Local alternate product to soy and soybean	•Eco-friendly livestock fish feeds •Sustainable agribusiness solutions for feed production and trade •Recycling of excess agriculture residues or biomass into the valuable feed-quality •Supply of feeds with essential amino acids •Production of organic fertilizers from feed byproducts.	•Eco-friendly products of biomass origin •Better product performance (durability and flexibility) •Product recycling for re-use •Better product safety without or with minimal plastic pollution •Simple technology

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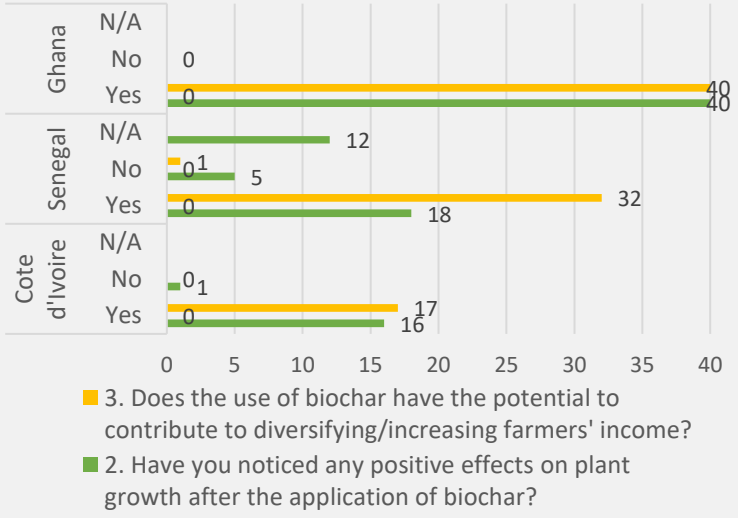
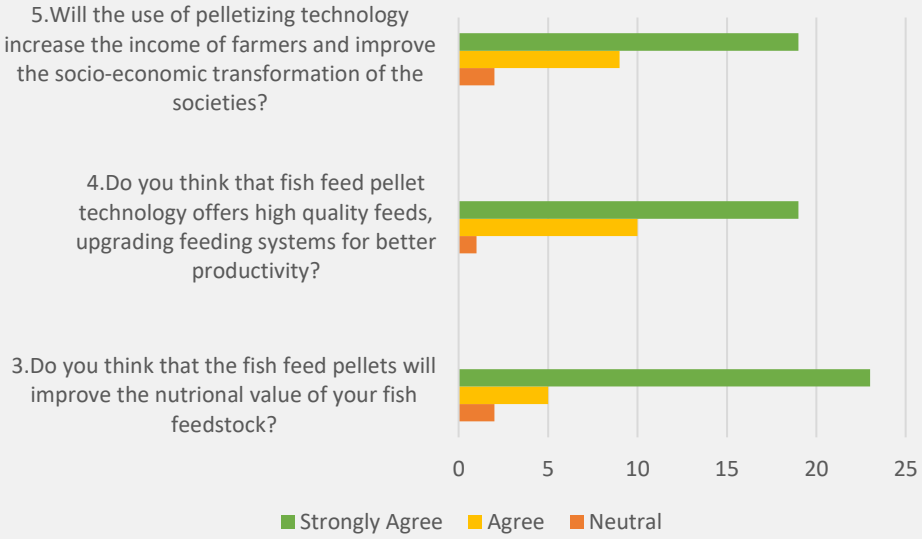
3rd iteration: Conclusions

Business models such as **biochar soil amendment (BM1)**, **biomass pellets for animal feed (BM3)**, fish feed pellets (BM9), and **small-scale biorefinery (BM6, 7, 8)** have shown promising results, as potential users have expressed favourable views due to their benefits for soil health, animal nutrition, and income generation.

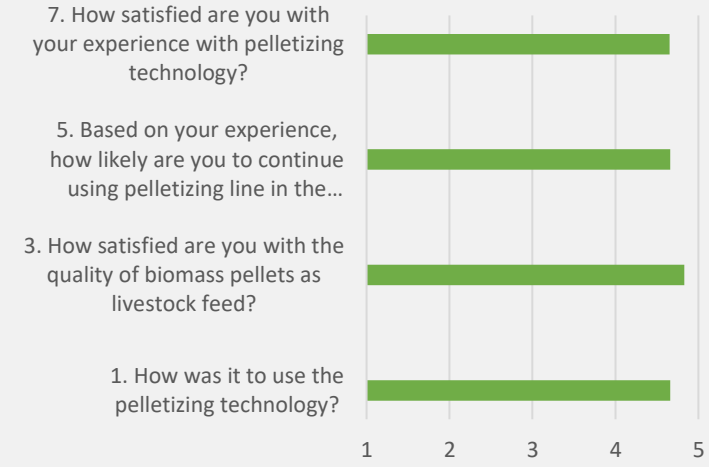
Brazilian kilns utilisation in Ghana, Senegal and Cote D' Ivoire



Biorefinery Technology: Impact on Animal Feed & Socio-Economics of Ghana



User Experience with pelletizing line in Cote d'Ivoire



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3rd iteration: Conclusions

Conclusions

Challenges that hinder broader adoption were also identified, including **limited knowledge** and **skills among farmers, operational costs, logistical constraints**, and the **need for initial investment**, especially for more complex technologies such as **small-scale green biorefinery and HTC**.

Recommendations to address the challenges:

- Develop and implement training programs to equip farmers with the necessary skills to operate and maintain the technologies effectively.
- Explore flexible ownership models like rental options or collaborative partnerships with organizations to facilitate access to the technologies without significant upfront investment.
- Provide financial support through grants or micro-loans to assist farmers with the initial costs of adopting these technologies.
- Strengthen communication channels to raise awareness about the benefits of these technologies and promote their adoption among farmers and other stakeholders.
- Investigate the potential of collaboration between farmers, private companies, and local institutions to leverage expertise, resources, and market access.

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Financial plans: Development and structure

BM1: BIOCHAR AS A SOIL AMENDMENT PRODUCT

- ***Cost structure Anaylsis***
  - 1) Technology Development Costs :
    - Research & Development Expenses
    - Customisation and tailoring costs
    - Initial set-up and training costs – Initial investment in infrastructure and software
  - 2) Implementation Costs
    - Infrastructure setup costs
    - Testing and adapting technologies
    - Capacity Building and training costs
  - 3) Operational costs
    - Labour costs for collection, transport, production, storage, distribution, and agronomic advice
    - Monitoring costs
    - Managing multi-actor collaboration costs
    - Marketing costs

- ***Core Cost Identification for Funding Opportunities***

  1) Identification of investment needed
  - *Infrastructure and Technology Development*
  - *Technology optimisation and Training programs*
  - *Efficacy trials and Capacity Building*

  2) Loan & Grant Possibilities

- ***Revenue Streams for Improved Business Model***
  - ✓ ***Product-Revenue Streams***
    - Direct Sale of biochar
    - Diversification opportunities
    - Sale of carbon credits
  - ✓ ***Energy revenue Streams***
  - ✓ ***Intellectual Property and Consulting Streams***

BM2: BIOCHAR AS A SOIL BIOFUEL PRODUCT

- ***Cost structure Anaylsis***
  - 1) Fixed costs:
    - Initial investment in infrastructure
    - Costs for equipment and technology (pyrolysis reactor) and maintenance costsI
  - 2. Variable costs
    - Raw Material Acquisition and Handling
    - Procurement and Transport of Biomass
    - Raw material storage
    - Biochar storage facilities
    - Operational and distribution costs
    - Labour costs
  - 3) Marketing and distribution expenses
    - Marketing costs
    - After-sales support

- ***Core Cost Identification for Funding Opportunities***

  1) Identification of investment needed
  - *Infrastructure and Technology Development: Pyrolysis equipment / Briquetting line / Technology optimisation*
  - *Raw material acquisition and Handling: Biomass procurement, Raw material storage*
  - *Validation in relevant environment activities*
  - *Capacity Building*

  2) Loan & Grant Possibilities

- ***Revenue Streams for Improved Business Model***
  - ✓ ***Product-Revenue Streams***
    - Direct Sale of biochar
    - Higher Value of Bio-based products
    - Sale of carbon credits
  - ✓ ***Energy revenue Streams***
    - Solid biofuel production

- ✓ ***Circular business models***
- ✓ ***Funding, financial support and subsidies (to enhance the adoption)***

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Funding schemes

- *Each scheme matched with Business Models (1…10)*
  - *Saving and Credit Cooperative Organisation / Society (SACCOs)*
  - *Government support schemes*
  - *Development banks and agencies*
  - *European Commission supporting mechanisms*
  - *Private financing schemes*
  - *Other funding and financing schemes*

Savings and Credit Cooperative Organization/society (SACCOs)		
SACCOs	**Description**	**Business Model(s) targeted**
Uganda Cooperative Savings and Credit Union UCSCU (Uganda)	UCSCU was founded on the dual purpose of Cooperatives; i.e; The Social purpose aims at meeting the members' associative objective (the reason why they formed /joined the Union), and the Commercial purpose ensures that the Union is an economically viable, growing, and sustainable institution doing Business with its members and other stakeholders within the Financial Services sector.	BM6:A green biorefinery for the productic of press cakes as ruminant feeds BM7: A green biorefinery for the productic of protein concentrate as aquaculture feed BM8: A green biorefinery for the productic of whey as monogastric feeds
Ghana Co-operative Credit Unions Association CUA - Ghana	CUA is the umbrella body of all Co-operative Credit Unions in Ghana. It provides an enabling environment for financial and other technical services to its members and also ensures that the Credit Union concept is promoted properly to become a household word.	BM1: Pyrolysis for the production of bioch as a soil amendment product BM6:A green biorefinery for the productic of press cakes as ruminant feeds BM7: A green biorefinery for the productic of protein concentrate as aquaculture feed BM8: A green biorefinery for the productic of whey as monogastric feeds BM9: Densification and Pelletisation Milli for the Production of Fish Feed Pellets
Association Nationales Des Crep Et Coopec de Cote d'Ivoire (ANAC-CI)	COOPEC is a financial community and people with a vocation to lead in the microfinance sector, in its geographical area of intervention. In this context, it aims to be and remain an efficient and innovative institution.	BM1: Pyrolysis for the production of bioch as a soil amendment product BM3: Pyrolysis for recycling agro-waste in biomass pellets as bio-feeds for livestock BM5: Pyrolysis for the production of bioch powder as a medium for water filtration BM10: Production of bio-composite fro bioplastic and composites

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