Diversifying revenue in rural Africa through circular, sustainable and replicable biobased solutions and business models

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Executive summary

This report constitutes Deliverable D5.1 Report on novel bio-based value chains and markets analysis that has been the result of Task 5.1 of BIO4AFRICA H2020 project. The deliverable analyzes the prospective markets in which the outputs of the BIO4AFRICA project are reformed via the pilot cases of the project in Uganda, Ghana, Cote D' Ivoire and Senegal.

The market analysis methodological framework used has been based on the Five Cs marketing analysis and the Porter's Five Forces competitive analysis framework, in order to identify market sizes, trends, insights and perspectives that could be of interest to the development of business models that will guide the commercial exploitation of BIO4AFRICA outputs.

Information about relevant markets structure, conduct and performance that has been accumulated through desk research has been validated through a series of four Market Scenario Workshops (1 in each focal African country of BIO4AFRICA) and 28 interviews with experts and relevant stakeholders.

All BIO4AFRICA technologies and outputs constitute potential novel business solutions with outputs that the local populations are not familiar with due to their innovative character but answer to basic local needs. Greeen biorefinery and biochar production technologies are new to the focus countries. The level of competition in all relevant market segments is low, as well as the threat of new entrants and the BIO4AFRICA outputs provide significant opportunities for income diversification, through fit to the local context implementation schemes.

The studied product- market combinations along with main conclusions per focal country are presented below:

a) Ghana

Product	Market	Feedstocks	Technology
Press cake to be used as animal feed for ruminants	Agricultural sector	Local forage species	Green biorefinery
Protein concentrate to be used as animal feed for pigs Whey to be used as animal feed for piglets	Agricultural sector	Local forage species	Green biorefinery
Protein concentrate pellets to be used as animal feed for aquaculture	Agricultural sector	Local forage species	Green biorefinery, pelletizing
Biochar as semi charcoal dust to be used as soil amendment	Agricultural sector	Rice husk, groundnut husk, corn cobs, maize stalks	Pyrolysis

Livestock includes ruminants (sheep, goats etc), pigs, poultry and other species (snails, rabbits etc) and it is a promising sub-sector for increase in the future in Ghana. The same promising pattern is highlighted in the marine fisheries sub-sector following the increasing consumption trends, but the introduction of aquaculture is immature at the moment, developing a dubious investment field for potential stakeholders. The Ghanaian market regarding the need for animal feed and soil amendments is expanding since the real growth rate of agriculture as a whole is increasing. Nevertheless, Ghana faces a variety of coordination problems among

farmers, processors, and industrial end-users. This is not the only problem between the value chains links, but local policy implications with potential stakeholders hinder the development of value chains in the country. BIO4AFRICA outputs in Ghana could provide significant benefits to local communities and farmers, with major strengths their low-cost, infrastructure, adaptability to local conditions, robustness and low complexity. Their use would provide an opportunity to diversify farmers' income, take advantage of local feedstocks and create new job opportunities, as long as access to information, communication and education on the introduced technologies is ensured and after sales support is guaranteed.

b) Uganda

Product	Market	Feedstocks	Technology
Press cake to be used as animal feed for ruminants	Agricultural sector	Local forage species	Green biorefinery
Protein concentrate to be used as animal feed for pigs whey to be used as animal feed for piglets	Agricultural sector	Local forage species	Green biorefinery
Protein concentrate to be used as animal feed for poultry	Agricultural sector	Local forage species	Green biorefinery
Biochar to be used as soil amendment	Agricultural sector	Manure, struvite	HTC
Biomass briquettes to be used as animal feed	Agricultural sector	Local biomass species	Briquetting

Despite the pandemic's impacts, Uganda is expected to face one of the highest economic growth rates in 2021 of 6.3%, in comparison with other African countries. Livestock is a very important factor for many families in the country, in order to optimize income, improve social status and contribute to food security. The agricultural production mix of Uganda includes an assortment of crops mainly for home consumption, though exports have increased by 20% between 2018 and 2019. BIO4AFRICA technologies to be tested in Uganda are with low capital and operating costs and with low complexity and focus on selected local forage species, based on the indigenous knowledge of local farmers and communities, providing high availability of animal feed alternatives during all seasons with increased nutrient concentration for several animal species. Main weaknesses that have to be faced for paving out the road to business exploitation of BIO4AFRICA outputs in Uganda are the need to build capacity on proposed technologies uses, to educate farmers in order to enhance adoption and combat competition with established trade networks, as far as soil amendments are concerned.

c) Cote D' Ivoire

Product	Market	Feedstocks	Technology
Biochar powder for additive in water filtration systems	Water purification market Agricultural market	Cassava peelings, rice husk, small branches, thinning woods, and/or residues of wood processing	Pyrolysis
Biochar powder for soil amendment	Agricultural market		Pyrolysis

Raw biomass pellets for animal feed (poultry, guinea fowl, pigs)	Livestock market	Rubber seed, cashew nuts, soybeans, rubber seed	Pelletizing
Bio-composites for composite panels	Construction industry	Bioplastics, vegetable fibres (roast tree fiber, cocoa pods)	Bio-composites production process
Bioplastics for packaging industry	Packaging industry Agricultural market	Cashew apple juice	Bioplastics production process

Cote D' Ivoire is one of the rapidly- growing countries in Africa, with an average growth rate of over 7% from 2012 to 2020. Agriculture plays a leading role in national economy being the engine of economic growth, accounting for 16% of GDP and employing two-thirds of the population. BIO4AFRICA focuses on the use of agricultural byproducts of main productive crops that have a strong export character as well. Livestock rearing plays a key role in the economics of Cote D' Ivoire as meat consumption, particularly chicken meat, is increasing fast. Additionally, 35% of the rural population in Cote D' Ivoire struggles to access clean water.

BIO4AFRICA technologies and outputs to be tested in Cote D' Ivoire are fit to the local context and needs of local farmers, processors and population in terms of improving soil fertility, give access to low cost animal feed throughout the year and improve drinking water safety. Additionally, they provide the opportunity to exploit agricultural waste streams that in most cases remain unvalorized with economic and environmental benefits. Inadequate and expensive logistics infrastructures and possible resistance in adoption of the proposed solutions by the local population should be considered as important threats to be taken into account for the business rollout of the project solutions in the country.

d) Senegal

Product	Feedstocks	Technology
Biochar powder for additive in biogas production systems	Peanut shells, cashew nut shells, millet stalks, rice husk	Pyrolysis
Biochar powder for soil amendment		Pyrolysis
Biochar briquettes and powder for solid fuel		Pyrolysis, briquetting
Biochar briquettes and powder for solid fuel and soil amendment	Typha, mahogany fruits	HTC, briquetting
Raw biomass briquettes for solid fuel	Peanut shells, cashew shells, millet stems	Densification
Bio-composites for composite panels	Lignocelullosic fibres coming from agrifood and forest waste streams	Bio-composites production process

95% of Senegalese agricultural land is worked by very small-scale family-based farms engaged in subsistence agriculture. Despite agriculture's importance in national economy, the sector is negatively impacted by land access problems, irregular rainfalls, poor soils, deterioration of forests and water resources (in quality and quantity). BIO4AFRICA focuses on agricultural by-products stemming from the main productive crops (rice, ground nuts, cashew nuts, millet etc.) and with low competition of other uses. Regarding domestic energy use, there is overwhelming reliance on traditional cooking fuels such as firewood and charcoal that has led to adverse health, social and ecological impacts. The building sector in Senegal is growing by 3.9% per year, propelled by economic growth and rapid urbanization. BIO4AFRICA proposed outputs in the Senegalese case study answer to the vital need to improve soil fertility and subsequently crop yields through easy to access and cheap soil amendment material (biochar), to get access to a low cost and environmentally and socially friendly alternative cooking fuel (biochar). At the same time, bio-composites and biochar as additive in biogas digesters provide an excellent opportunity for new, innovative business activities in sectors with low to non-existent competition. As in other BIO4AFRICA focus countries though, attention should be paid on providing adequate awareness raising, capacity building, and training activities to local population so as to enhance adoption of the newly introduced technologies and also to ensure after sales service and support.

1. Introduction

This report constitutes **Deliverable D5.1 Report on novel bio-based value chains and markets analysis** that has been the result of **Task 5.1 of BIO4AFRICA H2020 project**. The deliverable aims at analyzing the prospective markets in which the outputs of the BIO4AFRICA project are reformed via the pilot cases of the project in **Uganda, Ghana, Cote D' Ivoire and Senegal.**

The document is structured as follows:

- **Section 2** outlines the methodology followed in order to accomplish the above aim.
- **Sections 3** presents per each focus country (Ghana, Uganda, Cote D' Ivoire and Senegal) the value chains, the relevant markets structure analysis, conduct analysis and performance analysis.

As the pilot cases of BIO4AFRICA are still under development, the assumptions that defined the main elements of the novel value chains are based on our current perception and planning and on market data and general knowledge and feedback by regional stakeholders. It is anticipated that the project's pilots will provide valuable insights that may force us to revise some of here presented routes of market analysis. This report will fuel the elaboration and development of inclusive and sustainable business models for the bio-based technologies transferred and adapted to each pilot case under Task 5.2 and the development of BIO4AFRICA technology business plan and business plans per pilot case that will be elaborated under Task 6.3.

2. Methodology

2.1 Market analysis conceptual framework

Task 5.1 "Analysis of novel bio-based value chains and markets in rural Africa" aims to analyse the prospective markets and highlight the relevant activities of the BIO4AFRICA pilot cases in Uganda, Ghana, Cote D' Ivoire and Senegal. For the market analysis, we used the **Five Cs' marketing analysis tool**[1] simplified and adapted to micro and small-scale companies, suitable to the African context. The so called 'Five Cs' marketing analysis tool focuses on the Customers, Company, Competitors, Collaborators, and Context for BIO4AFRICA outputs in each of the four focus African countries (Ghana, Uganda, Cote D' Ivoire, Senegal). We will also implement elements of the **Porter's Five Forces competitive analysis**[2] to look critically at the market's competitive forces. This analysis uses the most recent and relevant data and allows for a thorough identification of market trends and insights that could be of interest to the development of business models that will guide the commercial exploitation of the BIO4AFRICA project. To this end, we investigate the potential market of BIO4AFRICA with a view to setting the premises for its successful deployment and commercialisation based on market driven insights.

[1] *https://corporatefinanceinstitute.com/resources/knowledge/strategy/5c-analysis-marketing/*
[2] *Porter, M. E. (1985). Competitive advantage: Creating and sustaining superior performance. The Free Press.*

The analyses follow the "structure – conduct – performance" model and will include:

(i) **Market structure analysis**: The analysis (Following Porter's framework and the 5Cs) looks into suppliers, buyers, product substitutes, barriers to entry and competitive rivalry for each industry involved and it is based on data generated from the value chain analyses (WP1) and a series of Market Scenario Workshops.

(ii) **Market conduct analysis**: The analysis seeks to identify the economic relationships (vertical and horizontal) characterising each market and explore the potential patterns of commercial behaviour (e.g. buying and selling practices, pricing behaviour, etc.). It is based on the findings of the market structure analyses, which are validated and complemented via interviews with experts as well as value chain actors in the regions where the pilot cases and their testing sites will be situated.

(iii) **Market performance analysis**: The analysis leverages the knowledge generated by the previous analyses of this task in order to assess the value chains based on crucial aspects such as size, prices, trends, growth prospects, socio-economic and gender implications and value added.

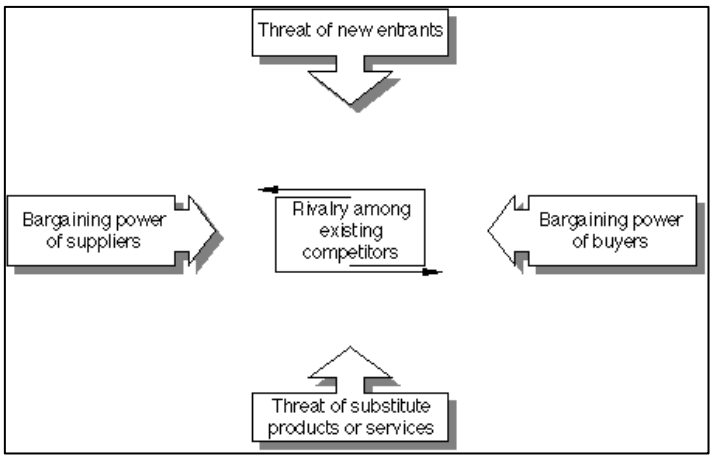
As mentioned above, the work of this task is based on Porter's framework on the five forces that shape an industry competition. This is a framework for diagnosing an industry structure which is built around five competitive forces. According to Porter, these forces erode long-term industry average profitability. In general, the framework can be applied at industry level, the level of strategic group or even at the level of an individual firm. Through it, we can explain the sustainability of profits against bargaining and against direct and indirect competition.

Porter's five forces or factors that shape business strategy are (shown in the exhibit)[3]:

- Threat of entry to the market from other organisations
- Supplier power
- Buyer power
- Availability of substitute products
- Existing competitors

[3] *University of Cambridge, Institute for Manufacturing – Management Technology policy. Porter's five forces. Available from: https://www.ifm.eng.cam.ac.uk/research/dstools/porters-5-forces/*

Figure 1: Porter's five forces[4]



The analysis is based on data generated from desk research, the value chain analyses of WP1, as well as a series of Market Scenario Workshops and interviews. Desk research was performed by Q-PLAN (along with partners of each country) to map and assess the current framework conditions (e.g. social, economic, regulatory and political), facilitating the identification of potential barriers or enablers in the markets of Uganda, Ghana, Cote D' Ivoire and Senegal.

The series of workshops (1 per pilot case – 25 to 30 participant) aimed at familiarizing policy makers with the key challenges that BIO4AFRICA aims to tackle from a policy perspective, and discussing on potential options (legal, financial, tax, social, etc.) that could facilitate adoption at rural areas. During the workshops, selected experts (from a regional, industry and technology perspective) were invited to discuss on critical success factors and limitations of the markets, as well as their potential for fostering inclusive opportunities and empowering rural communities, with emphasis on women and vulnerable groups. The workshops have been organized by AFAAS in Uganda, iHUB in Ghana, INP-HB in Cote D' Ivoire and UASZ in Senegal in February-March 2022.

Finally, 28 interviews have been implemented in April 2022 to understand in first-hand the perspective from farmers and rural stakeholders on the ground per pilot case area. The interviews enabled the deeper understanding of their potential needs and challenges and underlined problems and mismatches that may occur in the future. That way, the three-pillar market analysis conceptual framework ensures that the BIO4AFRICA project is on track following the guidelines and the proposed schedule.

2.2 Market scenario workshops

The BIO4AFRICA TASK 5.1 workshops looked into suppliers, buyers, product substitutes, barriers to entry and competitive rivalry for each industry involved, thus multi-disciplinary experts (from a regional, industry and technology perspective) were invited to discuss on critical success factors and limitations of the markets, as

[4] *Porter, M. E. (1985). Competitive advantage: Creating and sustaining superior performance. The Free Press.*

well as their potential for fostering inclusive opportunities and empowering rural communities, from organizations:

- Advisory bodies;
- Officials from ministries, administration and legislative bodies;
- Civil Society Organisations (CSOs), Non-Governmental Organisations (NGOs), and consumers associations;
- Academic and educational institutions;
- Research centres, cooperative research networks and knowledge transfer organisations;
- Farmers;
- Farmers' associations;
- Processing businesses;
- Agricultural advisors and consultants;

QPLAN was responsible for organizing the material and guiding the respective partners in order to inform and train the selected experts (from a regional, industry and technology perspective), in relation to the project's aims. Thus, Q-PLAN has prepared a concept note (APPENDIX I) in order to give local partners all the information needed for organising the workshops, accompanied by specific material for each country (word and ppt), as well as a report template (APPENDIX I).

These workshops were implemented in parallel to Task 1.4 workshops.

The number of participants in each workshop organised for the needs of each pilot case of the project, and in particular in Uganda, in Ghana, in Cote D' Ivoire and in Senegal are illustrated in Table 1. Furthermore, main discussion points of the workshops are highlighted in the Workshops' reports of each country.

Table 1: BIO4AFRICA Market scenario workshops information

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

2.3 Market performance validation interviews

An identification of the economic relationships (vertical and horizontal) characterizing each market has been conducted and potential patterns of commercial behavior (e.g. buying and selling practices, pricing behavior, etc.) were explored. The analysis was based on the findings of the market structure analyses and it was validated and complemented via interviews with experts as well as value chain actors in the regions where the pilot cases and their testing sites were situated. Guidelines along with a tailored semi-structured questionnaire (see APPENDIX I) were prepared by Q-PLAN to ensure consistency, as well as to minimize any potential interviewer-induced bias in the analysis.

The aim of this chapter was to analyze and better understand the agri-food systems and the value chains of each pilot area, as well as the requirements for adopting bio-based solutions and the availability of biomass in different contexts. The interviews have been a major aspect to calibrate the findings and identify any

requirements not previously envisaged. Several stakeholders have been interviewed from all relevant groups based on the specific constellation of value chain actors in each region (e.g. pastoralists, farmers, farmer associations, women cooperative groups, agri-food industry, policy makers, researchers, extension services, etc.) in order to assist the BIO4AFRICA prospective markets analysis. More details about the 23 interviews conducted are illustrated in Table 2:

Table 2: BIO4AFRICA Task 5.1 interviews information

Partner	Country	Number of interviews	Type of stakeholders
INP-HB	**Cote D' Ivoire**	6	• Producers (Agripreneurs) • Official • Teacher-Researcher • Animal breeder - Consultant • Experts in Agropedology and Agroeconomy
iHUB	**Ghana**	3	• Farmers • Extension Officers • Policy/Unit Head • Farmer Group/Association • NGO member
UASZ	**Senegal**	9	• Farmer • Public authority representative • Companies' representatives, • Economic interest groups (GIE) representatives • Representatives from vulnerable group • Researcher
AFAAS	**Uganda**	5	• Farmer • Ministry of Agriculture • Policy regulator /Uganda National Bureau of Standards • Ministry of Science Technology and Industrialization • National Crop Resource Institute
Q-PLAN	**N/A**	5	• Technology providers
Total		**28**	

3. BIO4AFRICA prospective markets analysis

3.1 Ghana

3.1.1 Value chains definition

In Ghana, BIO4AFRICA will target to test technologies for processing local forage species and various types of local agri-food waste streams to produce green biorefinery streams and biochar. In Table 3, the identified product- market combinations of BIO4AFRICA in Ghana are being presented, along with the corresponding feedstocks and technologies.

Table 3: Product- market combinations in Ghana

Product	Market	Feedstocks	Technology
Press cake to be used as animal feed for ruminants	Agricultural sector	Local forage species	Green biorefinery
Protein concentrate to be used as animal feed for pigs Whey to be used as animal feed for piglets	Agricultural sector	Local forage species	Green biorefinery
Protein concentrate pellets to be used as animal feed for aquaculture	Agricultural sector	Local forage species	Green biorefinery, pelletizing
Biochar as semi charcoal dust to be used as soil amendment	Agricultural sector	Rice husk, groundnut husk, corn cobs, maize stalks	Pyrolysis

BIO4AFRICA technologies and technology combinations in Ghana

In Ghana, a **small-scale green biorefinery technology** will be adapted to local types of biomass and the biorefining process will be continuously optimised to maximise the extractable protein per ha, while minimising its energy requirements based on the different types of grass-based biomass used as input (local forage species like Andropogon gayanus, Pennisetium Purpureum, Lucaena Leucocephala, etc). Furthermore, **pyrolysis technologies for biochar production** will be tested in real life conditions in order to fit to the local biomass feedstocks and produce biochar with customised properties. Moreover, the produced several inputs will be tested in order to produce biochar powder from major agricultural by-products (Cassava peelings, rice husk, forest-based byproducts etc.). Various feedstock blends and pyrolysis operating parameters will be defined and tested, depending on the availability of feedstocks (Crop residue from legumes, cereals, tubers, fruits, and vegetables e.g. cowpea, groundnuts, soybeans, maize, millet, sorghum, wheat, yam, cassava, sweet potatoes, cabbage, lettuce, spinach). Additionally, in order to diminish energy needs of the green biorefinery unit, gas released during pyrolysis will be burned in a combustion chamber to produce the heat required for the biorefinery, combining the relevant technologies. Finally, **pelletising technology** will be tested, for the production of protein concentrate pellets to be used as animal feed for aquaculture.

Animal feed as a) press cake for ruminants, b) protein concentrate for pigs, c) whey for pigs

Specific outputs as **animal feed** will be (i) fibre/protein grass press cake as ruminants feed; (ii) protein concentrate as monogastrics feed; (iii) Protein whey as monogastrics feed. Protein concentrate and whey will be transported to pig farms to be used as animal feed substituting - the mostly imported - soya. Both the press cake and dried protein concentrate are storable and easily transportable feed products, contributing to feed availability throughout the year even in locations with less favourable growing conditions, and making it possible to bring animal feed to zero-grazing small dairy farmers near urban areas (like Kampala) where is a shortage of dairy cattle feed, in the dry season. Animal feed trials (cows and pigs) will be performed in order to validate the feeding/nutritive value of the products.

Animal feed as aquaculture protein concentrate

Quantities of the **protein concentrate** will be pelletized to be used as aquaculture feed from local communities that breed fish (Tilapia and catfish). Aside pig and piglet feed trials, the protein concentrate will also undergo evaluation for use as an aquaculture feed. The Nile Tilapia (Oreochromis niloticus) species and Catfish will be used for aquaculture feed trials. The control trial will include: feeds used, fish species used, water quality (acidity, alkalinity, salinity, water temperature, and the rate of water circulation), system of fish production, feeding schedules, and number of fish used in a trial. This trial will use growth rate analysis to measure fish growth rate in relation to weight, duration of maturity, and the health of fish species used, while feed analysis will assess the nutritional value for Nile tilapia and catfish production.

Biochar as a soil amendment

In BIO4AFRICA Ghana pilot case, the use of **biochar** or biochar mixtures will be assessed for soil improvement to increase crop yield, to increase water retention and to increase soil stability, affecting the retention and mobilization of existing nutrients for plant uptake will be tested. The link between feedstock used and crop residues will be studied under BIO4AFRICA pilot and validation activities, so as to optimize biochar performance. The feedstocks used to produce biochar in the area, will be characterized by geographical locality, through a closed-loop approach, so as not to disrupt the nutrients cycle.

3.1.2 Market structure analysis

Target markets and size (per product/ per country)

The share of the agricultural sector to the GDP of Ghana is 18.24%[5], which is a considerable figure highlighting the importance of the primary sector for the whole country. The market size of Ghana is significant as well since the Gross Domestic Product (GDP) for f2021 was 74.26 billion U.S. dollars, which is the eighth highest GDP in Africa[6]. Most of the population income in Ghana comes from farming activities (63.9% of the total

[5] *Statista. (2022). Contribution of agriculture, forestry, and fishing sector to the Gross Domestic Product (GDP) in Africa as of 2020, by country. Available from: https://www.statista.com/statistics/1265139/agriculture-as-a-share-of-gdp-in-africa-by-country/*

[6] *Statista. (2022). African countries with the highest Gross Domestic Product (GDP) in 2021. Available from: https://www.statista.com/statistics/1120999/gdp-of-african-countries-by-country/*

income), while the second most important income comes from non-agricultural wages and self-employment accounting 21.1% of the total population income[7].

Focusing on the agribusiness market, size and shares the major crops being grown in the country are cassava, sweet potatoes, plantain, cocoa, maize, sorghum, groundnuts and coconuts. 75% of the agricultural GDP is generated via the agricultural produce, while 9% comes from livestock, 6% from fishing and the rest 10% from forestry and logging[8]. Livestock includes ruminants (sheep, goats etc), pigs, poultry and other species (snails, rabbits etc) and it is a promising sub-sector for increase in the future. The same promising pattern is highlighted in the marine fisheries sub-sector following the increasing consumption trends, while the introduction of aquaculture is immature at the moment, thus generating an insecure place for future investments. The shares (percentages) of the agricultural GDP sub-sectors in Ghana are presented in Table 4 from 2014 to 2018, depicting significant losses for the livestock and fisheries sector (-4.2% and -1.3% respectively). On the other hand, the share of crops (excl. cocoa) in relation to the agricultural GDP has increased 9.7% from 2014 to 2018, highlighting the integration of technological advancements and the suitable implementation of agrochemicals in the country.

Table 4: Shares of sectors to the Agricultural GDP (2014-2018)[9]

Sector	2014	2015	2016	2017	2018
Crops (excl. Cocoa)	55.9	57	62.9	64.1	65.6
Cocoa	10.5	10	8.5	8.3	7.9
Livestock	17.9	16.6	14.5	14	13.7
Forestry	9.3	9.5	7.8	8	7.7
Fisheries	6.4	7	6.3	5.5	5.1

The negative trends for the livestock and the fisheries sectors illustrated in Table 4 are not necessarily connected to a downturn for the respective sectors. Indeed, the real growth rates for crops and livestock were positive for the relevant years according to the Statistical Service of Ghana (Table 5). Nevertheless, fisheries' real growth rates fluctuate through time, achieving negative figures for 2014, 2017 and 2018 and positive figures for 2015 and 2016.

Table 5: Agriculture and sub-sectors real growth rates (%)[10]

	Sector					Agriculture Sector Real Growth Rate
Year	Crops	Cocoa	Livestock	Forestry/ Logging	Fisheries	
2014	2.8	4.3	5.1	-1.5	-23.3	0.9
2015	1.7	-8	5.2	-3.9	8.5	2.3
2016	2.2	-7	5.4	2.9	3.1	2.9
2017	7.2	9.2	5.7	3.4	-1.4	6.1
2018	5.8	3.7	5.4	2.4	-6.8	4.8

The Ghanaian market regarding the need for animal feed and soil amendments is expanding since the real growth rate of agriculture as a whole is increasing. However, the sector of fisheries is facing challenges with

[7] *Garcia, M., Sedi, M., & Willy, D. (2021). BIO4AFRICA - Diversifying revenue in rural Africa through circular, sustainable, and replicable biobased solutions and business models - D1.1: Contexts and needs of African rural communities.*
8 MEI (2020). Agriculture Sector in Ghana Review - Israel's Trade and Economic mission to Ghana
[9] *Ghana Statistical Service (Available from: https://www.statsghana.gov.gh/)*
[10] *Ghana Statistical Service (Available from: https://www.statsghana.gov.gh/)*

constant and continuous downturns and upturns, developing a dubious investment field for potential stakeholders.

Value chains SWOT analysis

The Ghanaian market encompasses significant opportunities for manifold business activities within the industry value chain. Nevertheless, Ghana faces a variety of coordination problems among farmers, processors, and industrial end-users, especially in relation to the cassava value web[11]. This is not the only problem between the value chains links, but local policy implications with potential stakeholders hinder the development of value chains in the country. The value chains in Ghana include an assortment of business activities/operations (e.g. Farming, Processing, Transportation, Storage, Sales & Marketing, External advisory etc). In this context, specific value chains are merged in order to create credible SWOT analysis results.

Strengths	Weaknesses
All outputs Low capital and operating costs for the Green biorefinery Low complexity technologies, not requiring high level of knowledge and skills (Pyrolysis - Pelletizing) Innovative, environmentally friendly outputs Availability of cheap raw materials with practical indigenous knowledge on local species by the local farmers and stakeholders, cheap overheads (transportation costs the processed products etc) **Biochar for soil amendment** Improved soil fertility, especially for sandy soils Increased crop yield Reduced nutrient loss Low-cost in comparison with the alternatives Indirect reduction of other greenhouse gases through soil emissions **Animal feed in various forms** Decreased deforestation pressures Increased nutrient concentration Different types of animal feed for manifold species	**All outputs** Limited subsidiary framework and access to capital Limited access to information, communication and learning mechanisms Capacity building and dissemination are required **Biochar for soil improvement** The industry is concentrated on local-to-local patterns Education of farmers to enhance adoption is required Effectiveness of biochar use as soil amendment is highly dependent on biochar synthesis, soil and crop types and quantities applied. **Animal feed in various forms** The industry of aquaculture is mainly focused on Tilapia with poor infrastructure Old management practices are a part of tradition

[11] *Poku, A. G., Birner, R., & Gupta, S. (2018). Is Africa ready to develop a competitive bioeconomy? The case of the cassava value web in Ghana. Journal of Cleaner Production. https://doi.org/10.1016/j.jclepro.2018.07.290*

Opportunities	Threats
Business opportunities for local agrochemical providers and intermediaries Combine local feedstocks with urban green wastes, biogas digestate, manure etc. generating new waste management business opportunities Set up standardization procedures for biochar Generation of increased demand for other industries products Green biorefinery unit could create an assortment of new job opportunities	Potential negative health impacts of handling biochar Low adoption from the local population Rigid rural policy in Ghana Dispute between different uses of residues to be used as feedstocks (rice husk) Inadequate after sales service Frequent droughts, lowering the potential inputs

Customers, customer segments and their needs

As stated in the Target markets and size chapter, population income for Ghana comes mainly from farming activities, hence the purchasing power of customers is compromised. Most poor people live in rural areas and most earn their incomes, at least in part, from working in the food system. Extreme poverty rates are projected to drop to around 7 per cent of the global population by 2030, with 90 per cent of the extremely poor living in sub-Saharan Africa. From this share, 70% belongs to rural areas accounting for 306.6 million people living in extreme poverty. Moderate poverty will remain high across sub-Saharan Africa and will be predominantly in rural areas[12]. A more elaborate analysis for the household incomes and consumption in Ghana is illustrated in Table 6

Table 6: Household incomes and consumption in Ghana (htt1), 2015[13].

	National	Rural	Rural Poor
Population, millions	27.4	13.7	6.2
Consumption per capita, USD	878	563	374
All foods, %	100.0	100.0	100.0
Cereals, roots	28.2	37.3	40.9
Vegetables	9.2	10.1	10.7
Fruits	7.1	7.4	5.0
Meat, fish, eggs	18.8	17.4	16.4
Pulses, oilseeds	4.6	5.8	6.0
Other foods	32.1	22.0	21.0
Food consumption share, %	49.8	59.1	64.0
Processed share, %	44.1	43.2	46.5
All income, %	100.0	100.0	100.0
Land	6.9	19.4	27.9
Labor	35.6	42.8	48.8

[12] *Anastasiadis, F., Skourtanioti, E., & Kosmidis, V. (2021). BIO4AFRICA - Diversifying revenue in rural Africa through circular, sustainable and replicable biobased solutions and business models - D1.2: Mapping of local forage agri-food systems.*
[13] *Hartley, F., & Arndt, C. (2018). Identifying priority value chains in Ghana. Strategy Support Program.*

	National	Rural	Rural Poor
Less educated	23.2	36.1	46.7
More educated	12.5	6.7	2.1
Capital	52.2	33.2	19.3
Other	5.2	4.6	4.0

Table 6 depicts aggregate income and consumption patterns for the country, dividing the population in several categories, aka two major categories for urban and rural residents, while a sub- category is introduced as poor rural. The patterns are quite clear since residents in urban areas present higher consumption rates are better educated and spent less of their income for food commodities. On the other hand, residents of rural areas spent up to 64% of their income for food products, while the major food category consumed is cereals. Focusing on the needs of Ghana for animal feed, the number of livestock is depicted in Table 7 categorized into five major classes (cattle, sheep, goat, pigs, and poultry). The population for all the types of livestock is raising, validating the growth rates of Table 7 and highlighting greater expectations for animal feed production.

Table 7: Livestock population ('000) and slaughter per/head ('000)[14]

Type of Livestock	Category	2014	2015	2016	2017	2018
Cattle	Live animal	1,657	1,734	1,815	1,901	1,943
	Slaughtered	166	141	116	129	-
Sheep	Live animal	4,335	4,522	4,744	4,978	5,102
	Slaughtered	65	48	42	48	-
Goat	Live animal	6,044	6,352	6,740	7,151	7,366
	Slaughtered	129	77	67	74	-
Pigs	Live animal	682	730	777	816	845
	Slaughtered	545	582	582	-	-
Poultry	Live animal	68,511	71,594	73,885	75,363	76,870

Furthermore, meat production is another aspect of livestock breeding for Ghana which is considered new, since the category of slaughtered animals for meat production was integrated in 2007 by the Vertinary Directorate – MoFA. Regarding the animal feed for aquaculture using local forage species, the aquaculture sector is expanding as shown in Table 8. The total quantity of fish produced has increased significantly, more specifically doubled, from 2014 to 2018 (+38.,085 Mt), generating 1,038.3 million of GH₵ in 2018. Nevertheless, aquaculture in Ghana hinges on the exploitation of Tilapia (*Oreochromis niloticus*) and to a lesser extent on catfish and farmed shrimps. Therefore, nutrition status for fish feed in the area should mainly meet the requirements of tilapia.

[14] *Vertinary Directorate – MoFA (Available from: https://www.statsghana.gov.gh/)*

Table 8: Aquaculture production (GH₵=Ghana Cedi)

	Tilapia		Catfish		Farmed Shrimp		Total	
Year	Qty (mt)	Value (GH₵ million)	Qty (mt)	Value (GH₵ million)	Qty (mt)	Value (GH₵ million)	Qty (mt)	Value (GH₵ million)
2014	35,837.6	394.2	2,697.5	29.7	12.0	0.4	38,535.1	424.2
2015	40,905.11	474.3	3,704.89	47	-	-	44,610.0	521.3
2016	48,638.3	583.4	3,832.1	42.8	-	-	52,470.4	626.2
2017	70,594.9	862.0	12,680.4	143.3	-	-	83,275.3	1,005.3
2018	69,859.9	947.0	6,760.2	91.3	-	-	76,620.1	1,038.3

Finally, in relation to the soil amendment using plant residues, maize, rice(paddy), yam, plantain and soyabean have expanded between 2014 and 2018 as illustrated in Table 9. The total cultivated area has increased, depicting the importance of the agricultural sector to the GDP of Ghana.

Table 9: Annual Cultivated Area of some Major Crops in Ghana ('000 Ha)

Crop	2014	2015	2016	2017	2018
Maize	954.4	991.7	1,023.2	1,042.1	1,023.5
Rice (Paddy)	162.4	162.4	197.5	189.5	215.9
Millet	186.7	176.7	178.7	172.5	160.7
Sorghum	267.2	252.6	243.5	230.8	225.8
Cassava	885.8	875.0	889.4	868.5	875.2
Cocoyam	224.6	205.3	204.4	196.3	194.0
Yam	378.7	384.9	403.8	426.3	421.6
Plantain	324.9	328.0	336.5	337.3	340.0
Groundnuts	336.5	333.4	356.8	345.2	328.9
Oil Palm	352.8	343.3	373.2	387.0	313.7
Cowpea	162.7	167.0	182.3	168.8	162.0
Soyabean	77.3	76.2	85.9	85.2	84.8

Level of competitiveness

The lack of direct government supporting schemes for providing loans and indirect subsidies (tax breaks or incentives) and lack of credit are amongst the most important institutional limiting factors across the regions of Nabari, Silinga and Zangum. Furthermore, the confined access to mechanization services on equipment and tools, and the limited shelf life of harvested products (scarce product differentiation, lack of competitiveness) are crucial barriers harnessing local agricultural economy. Intercommunications between supply chains from villages and communities around are mostly non-existent, making it difficult to establish effective communication channels, concluding to supplies shortage and low selling prices. It is important to notice that the results shown are part of D1.1: Contexts and needs of African rural communities[15], a survey incorporating the perspective of farmers and livestock breeder in manifold countries of Africa.

[15] *Garcia, M., Sedi, M., & Willy, D. (2021). BIO4AFRICA - Diversifying revenue in rural Africa through circular, sustainable, and replicable biobased solutions and business models - D1.1: Contexts and needs of African rural communities.*

Direct government subsidies should concentrate in setting up a plan to not only deliver bio-based, improved tools and equipment, but a complete training programme involving community heads to confront the current lack of knowledge on the subject and increase competitiveness. From the point of view of institutional actors, other concrete actions can be added, such as the establishment of political schemes and pressure actions coming from agricultural structures (ANADER, Agricultural ministries and animal resources ministries), which can specifically focus on plans for e.g., decrease supply costs on grains or improve logistic infrastructures for shortening value chains and can seek high quality, selected suppliers, and advance towards a more competitive industry. The commercial poultry industry in Ghana has adequate infrastructure in terms of housing for the production of eggs in order to fulfil the nation's requirements. Nevertheless, inadequate infrastructure (e.g. hatcheries, feed mills, processing plants, and transportation of live birds) is a significant issue[16]. The method of layer keeping for egg production is preferred, since farmers obtain better prices for their products, while there is no competition in relation to imported table eggs[17].

The livestock feed mill industry has been in existence in Ghana since the early sixties, though most of feed mills registered with the Ghana Feed Millers Association have faced economic issues. Selectively, we choose eight commercial feed mills located in the Greater-Accra, Eastern and Ashanti Regions, namely Agricare Ltd, Kosher Feeds, 32 Hiligifred Feed Mills, New Age Feed Ltd., Flour Mills of Ghana Ltd, Alhassan Farms, Central Feed Mill Ltd. and Greater Accra Poultry Farmers Association. The total installed capacity of these feed mills was 51.5 metric tonnes/hour with an annual production potential (assuming they operate at full capacity) of 123,600 metric tonnes/annum. The most significant problem is the inconsistent and low quality of some of the feed, while the rising cost of the feed ingredients represents another aspect of danger. Most of the small-scale poultry and pig farmers use self-prepared diets for feeding their animals. The commercial feed companies produce mainly poultry and pig feeds which are distributed countrywide. For all the livestock commodities there are a few companies that import inputs such as veterinary drugs, vaccines, feed additives, feed ingredients and concentrates[18].

Potential collaborators

The processing results in the value chains for different products ready for market and by-products that are mainly used at a domestic level could develop forms of collaboration among stakeholders. The main concern is the valorisation options of by-products. Renewable feedstocks and by-products that can be exploited continuously to create value-added commercial opportunities, included in the relevant value chains, could encompass potential collaborations. Based on the results of Task 1.2 of BIO4AFRICA, higher-value applications of cassava by-products include:

[16] *USDA. (2008). Gain Report No. GH 8006. Ghana poultry and poultry products. USDA Foreign Agricultural Service.*

[17] *MOFA. (2016). Ministry of Food and Agriclture. Ghana livestock development, policy and strategy. http://extwprlegs1.fao.org/docs/pdf/gha169291.pdf*

[18] *Oppong-Anane, K. (2016). Review of the livestock/meat and milk value chains and policy influencing them in Ghana. https://www.fao.org/3/i5264e/i5264e.pdf*

1. Use agricultural residues (legume husk, stems, cobs etc.) as animal feed creating added value chains between the local farmers and agricultural enterprises.
2. Use agricultural residues (legume husk, stems, cobs etc.) as source of energy for potential biomass exploitation power plants and exploit the biochar created by the industry, thus creating added value chains and promoting circular economy.
3. Process legume residues for fibres/protein grass press cake pellets.
4. Collect and use legume milling by-products (e.g., husk) as organic input on farms.
5. Use of cassava leaves as cattle feed (e.g., for poultry, goats, sheep).
6. Use of cassava processing by-products (e.g., dry peels, tubers) as cattle feed (e.g., for pigs).
7. Fresh leaves as human feed (sauce)
8. Export of cassava starch emanating from the mechanised processing stages for industrial manufacturing purposes. Cassava starch can be used in paper industry applications as a binding agent in pulp production to create higher-value paper.
9. Export of cassava starch emanating from the mechanised processing stages for industrial manufacturing purposes. Cassava starch is used as an agent in the textile industry for producing better quality and resistant printed fabric.
10. Export of cassava starch emanating from the mechanised processing stages for food manufacturing purposes. Cassava starch is used in food industry applications, e.g., thickener, binder, expanding agent, stabilizer, carrier of sweetener and condiment.
11. Export of cassava starch emanating from the mechanised processing stages for beverages industry applications, e.g., sweetener.
12. Export of cassava starch emanating from the mechanised processing stages for candy production purposes, e.g., gelatinize, thickening, enhance foam, control crystallization, and enhance candy gloss.
13. Use of plant residues for the production of biofuels (e.g., bioethanol).
14. Use of plant residues as wrapping medium for domestic dishes such as green leaves for Kaake and dried leaves for Kenkey. The demand for such applications is low.
15. Use of plant residues for the production of herbals dedicated to medical purposes.
16. Use of plant residues for compost. Composting comprises the major application for plant residues.
17. Use of plant residues (e.g., peels, fresh leaves) as animal feed. This is a major applications of plant residues for farmers in Ghana.
18. Use of plant residues as dyes for the textile industry (e.g., sap from the pseudostem) and as natural fibres in the apparel industry (e.g., stalk and pseudostem).
19. Use of plant residues for the chemical industry (e.g., pulp for paper, bio-chemicals, composites).

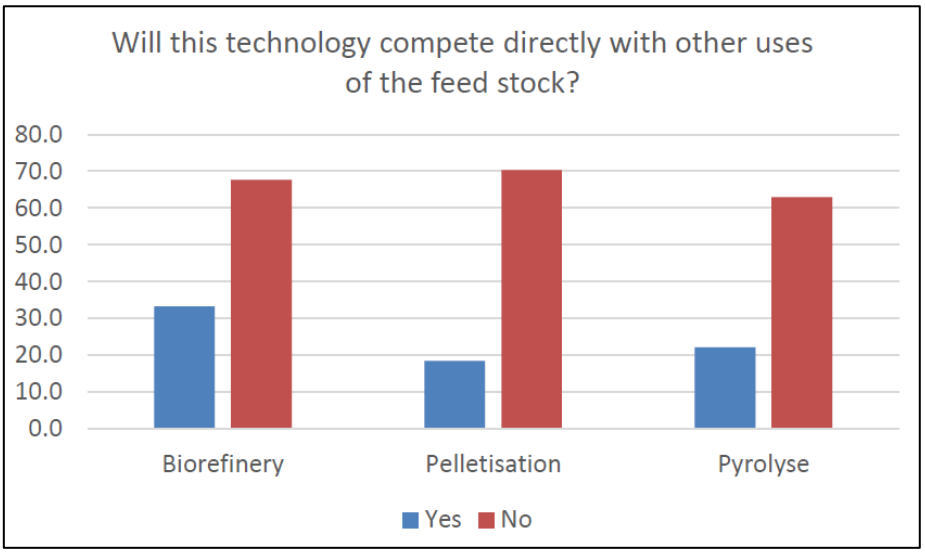
3.1.3 Market conduct analysis

Competitive rivalry within the market

As resulting from Task 1.4 of BIO4AFRICA, in Ghana, over 50% of the stakeholders noted that the technology will not compete directly with other uses with other feedstocks meant for the biorefinery at 67%,

pelletization at 70% and pyrolysis at 65%. 35%, 15% and 22% of the stakeholders noted that there will be competition with other uses of the feedstocks for biorefinery, pelletization and pyrolysis respectively as shown in Figure 2 depicting Ghana Competition with other uses of the feedstocks.

Figure 2: Competition in Ghana with other uses of feedstock[19]



Products on the market, in comparison to proposed products can be differentiated along the dimensions of nutrient composition/nutritional content; feed quality and standardised weights. Differentiation can also be based on the use it would be put to- for instance in feeding fish or livestock. There is no well established competition for the proposed products. However, competition for identical raw materials produced for different products could increase the level of competition significantly. In such instance, stakeholders may try outwit each other to gain advantage over competition and to acquire the raw materials more easily.

Regarding the competitive rivalry for the fertilizer sector, the International Fertilizer Development Center states that in Ghana there is no primary production of inorganic fertilizers[20]. Bulk fertilizers are transformed into various forms and distributed via a network system of intermediaries and retailers. The five major importing companies, along with Yara Ghana, Macrofertil, Chemico Limited, GloFert and OmniFert have invested in blending plants allowing them to create manifold fertilizer formulations. These blending plants are located in the southern areas of Ghana (Yara and Chemico at the port city of Tema, Macrofertil at Kpong, OmniFert at Dawhenya and GloFert at Teacher Mantey). Organic fertilizers are produced locally by ACARP, JEKORA Ventures and Safisana, but to a lower degree[1].

[19] *Sedi, M., Kyalo, W. D., & Marechera, G. (2021). Diversifying revenue in rural Africa through circular, sustainable and replicable biobased solutions and business models - D1.4: Co-definition of technologies to be transferred with local farmers and communities.*
[20] *IFDC. (2020). International Fertilizer Development Center. FERTILIZER STATISTICS OVERVIEW GHANA 2015 2019.*

The threat of new market entrants

In the business sector of Ghana, there is no legislative framework regarding the retention of local agents or distributors for exports to Ghana[21]. Thus, the potential for new cooperative consortia with interested investment parties could be of the utmost importance for the new market entrants. The cooperative form with the foreign stakeholders could be done via Joint Venture capitals, but there is a minimum foreign equity requirement in order to comply with Act 865[22]:

- 200,000 US dollars for a Joint Venture with Ghanaian partner, participating to the equity at least 10%
- 500,000 US dollars for 100% foreign ownership
- 1,000,000 US dollars for Trading Activity with at least 20 skilled Ghanaians as employees by the enterprise
- No minimum equity requirement for foreigners interested in manufacturing, export trading and portfolio investment.

In this context, new market entrants could develop synergies among the services of the value chains with potential stakeholders in manifold ways (shareholder, manager, employee etc.). On the other hand, a threat for new entrants is the competition with investors with imported businesses, taking advantage of their high rates of money velocity. Apart from the global competitive framework, the exploitation of biomass in the respective value chains, either as animal feed or as fertilizer, hinders completely by the climatic conditions of specific stretches of land. As Ghana faces significant issues with droughts and floods, potential new entrants should be ready to cope with long periods of financial hardships. Finally, seasonality is another threat for new market entrants, as by-products of agricultural production and actual yields are harvested in specific times of the year, meaning that coordination and management play a significant role for newcomers. Regarding this aspect, in Ghana most imported fertilizers arrive at the second quarter of the year, since the major planting season begins in April (Figure 1 & Figure 4).

[21] *International Trade Administration. (2022). United States of America. Ghana - Country Commercial Guide - Market Entry Strategy. Available from: https://www.trade.gov/country-commercial-guides/ghana-market-entry-strategy*

[22] *GIPC. (2022). Ghana Investment Promotion Centre - Business Registration - MINIMUM EQUITY CONTRIBUTION. Available from: https://gipc.gov.gh/4232-2/*

Figure 3: Amount of fertilizer imports in Ghana (2019)[23]

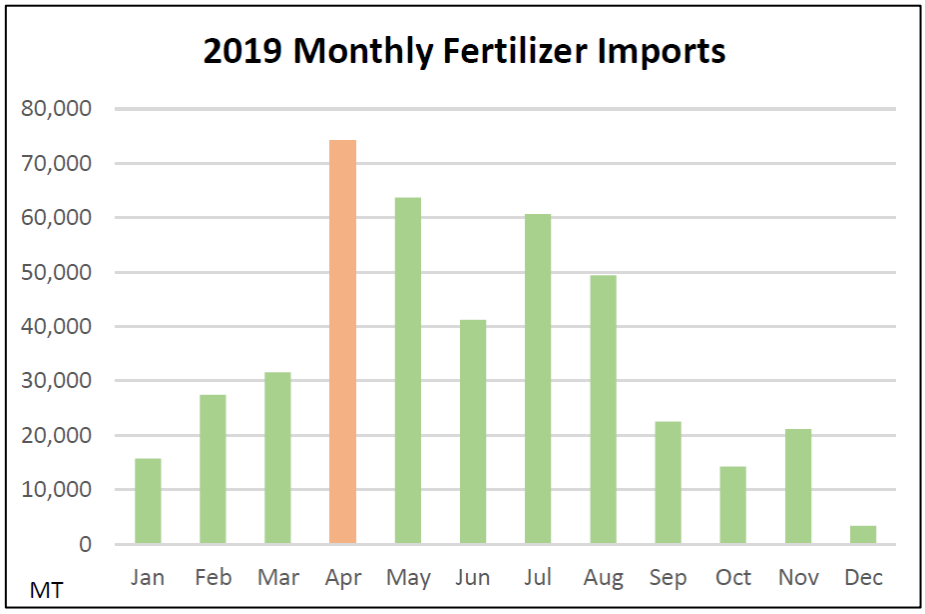


Figure 4: Fertilizer demand in conjunction with major crops and on-field practices[24]

Crop Calendar

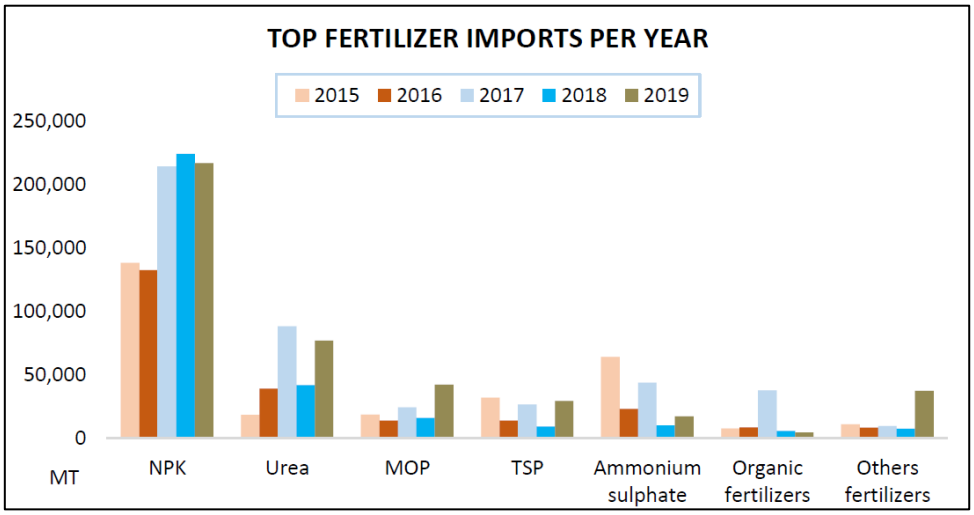
SEASON	CROPS	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Major Season (Long Rains)	Cassava(1st year)				◆	◆	◆						
	Cassava(2nd year)												
	Maize(North main*)						◆	◆	◆				
	Maize(South main*)			◆	◆	◆							
	Sorghum & Millet					◆	◆	◆	◆				
	Rice(North)					◆	◆	◆	◆				
	Rice(South)				◆	◆	◆						
	Yams	◆	◆	◆	◆								
Minor Season (Short Rains)	Cassava, Maize, Millet, Sorghum, Rice, Yams							◆	◆	◆			

Key: ◆ Fertilizer Peak Demand; Sowing; Growing; Harvest

The IFDC informs that there was a 35% increase in official fertilizer imports between 2018 to 2019 (about 425,110 metric tons). Therefore, the market is strongly dependent on imports, as Ghana is not a fertilizer producer[25]. In this context, the threat of new market entrants for fertilizer producers in the country is considered low, especially for organic fertilizers as organic fertilization is not among the most popular options for imported products (Figure 5).

[23] *IFDC, 2020; FAO/GIEWS*
[24] *IFDC, 2020; FAO/GIEWS*
[25] *IFDC. (2020). International Fertilizer Development Center. FERTILIZER STATISTICS OVERVIEW GHANA 2015 2019.*

Figure 5: Imported fertilizers per type and year[26]



Economic relationships within markets

Economic relationships from the value-chain perspective encompass active stakeholders in different networks, in order to form the appropriate linkages between the systems. At start, in agricultural production, farmers with small holdings are the stakeholder in common. As the agricultural output differentiates in manifold agro-ecological zones, (e.g. plantain in the central Ghana and cotton in the northern area), potential synergies, overlaps and competition are not expected to be unfolded[27]. Potential bottlenecks among economic relationships in Ghana could be created due to lack of coverage and frequency of advice support given by the government. The study highlighted the absence of enough trained staff and of constant and continuous training as significant issues to link markets in Ghana.

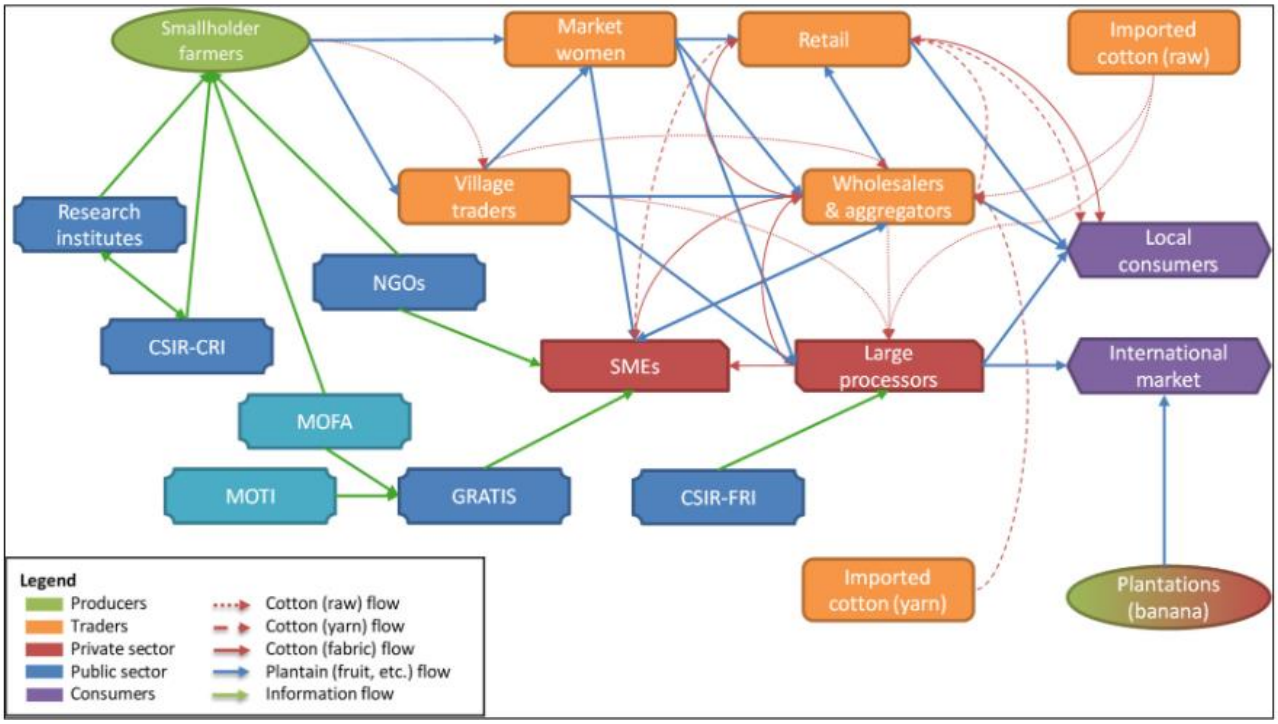
Farmers collaborate with research programs and it is the only way to reach out innovative skills, while the processing sector involves the establishment of stable relationships with small and medium enterprises (SMEs) in order to be efficient. Usually SMEs are backed by NGOs, supporting knowledge transfer to value chains and provide the necessary technical know-how. Therefore, the economic relationships are of the utmost importance within markets in order to evolve the domestic and foreign financial funding. A diagram of relationships among stakeholders for Plantain-cotton value web in Ghana is illustrated in

[26] *IFDC, 2020; FAO/GIEWS*

[27] *Loos, T. K., Hoppe, M., Dzomeku, B. M., & Scheiterle, L. (2018). The potential of plantain residues for the ghanaian bioeconomy-assessing the current fiber value web. Sustainability (Switzerland). https://doi.org/10.3390/su10124825*

Figure 6.

Figure 6: Relationships among stakeholders for Plantain-cotton value web in Ghana[28]



The pilot project in Ghana encompasses the utilization of livestock feed through time, which will enhance food security and facilitate sustainable livestock and aquaculture production. This will contribute immensely to the restriction of the conflict among surging nomads-farmer over grazing pasture and land. Furthermore, sustainable circular businesses could be established in the area, creating new jobs and improving the farm and nomad income towards rural development in Ghana. The main aim is the improvement of the livelihood and the enhancement of food security for transhumant pastoralist livestock production systems exploiting small-scale biobased technologies[29].

Patterns of commercial behaviour

As stated by the International Trade Administration[30], "Ghanaians like to take time to get to know potential business partners before launching directly into business negotiations". Potential stakeholders exploring partnerships in Ghana should develop strong link with the country and maybe enjoy a meal with local authorities and producers. To this extent, Ghanaians are proud of their rich culture, including food, music and arts. Moreover, the cornerstone of Ghana's history is its independence movement from Britain in 1957.

Regarding the livestock products in the system of small- and medium-scale operators, most of the farms exploit their asset mainly for subsistence and for satisfying household consumption. Large scale producers

[28] *Loos et al. (2018). The potential of plantain residues for the Ghanaian Bioeconomy- Assessing the current fiber value web,* Sustainability *2018,* 10*(12), 4825; https://doi.org/10.3390/su10124825*

[29] *Sedi, M., Kyalo, W. D., & Marechera, G. (2021). Diversifying revenue in rural Africa through circular, sustainable and replicable biobased solutions and business models - D1.4: Co-definition of technologies to be transferred with local farmers and communities.*

[30] *International Trade Administration. (2022). United States of America. Ghana - Country Commercial Guide - Market Entry Strategy. https://www.trade.gov/country-commercial-guides/ghana-market-entry-strategy*

for livestock products are mainly commercial enterprises focusing on producing for a general market and the enhancement of their financial status. In this context, domestic livestock production is facing to domestic production with little to no intention of export[31]. In relation to the competing uses for the selected forage species, Panicum maximum is used for a material for thatch roofing. Furthermore, farmers tend to procure large amounts of feedstock during the raining season when the price is low, because the forage species are scarce in the dry season.

Women usually play a predominant role on household decisions and are usually the main interest by national scheme programs for loan and credit aids. However, most of women farm owners were usually widows or agribusiness professionals. Focusing on social factors such as lack of competitive salaries and social isolation are shown as the most important barriers faced by women when performing daily business activities. Overall, female engagement has been low, especially for Ghana and will need to probe further during our engagement in subsequent interaction for the project to ensure they are not left out.

As has been evidenced in Task 1.1 of BIO4AFRICA[32], 50% of the respondents showed a high degree of correlation between low salaries, lack of access to credit and the fact of being a woman operating in the field. Aspects such as social isolation and female condition of those surveyed seemed to have a medium to high degree of correlation (38%).

3.1.4 Market performance analysis

Bargaining power of customers

According to Boafo et al.[33], when there is a wide transactions field, then buyers have the force in their hands partly because this reduces their costs to search for and select producers. In the primary sector and more specifically in relation to the developed value chains, the bargaining power of customers is strong, due to the abundance of firms in the industry and potential substitutes for the animal feed and fertilizers. In this context, one can easily find another supplier in the industry. Nevertheless, potential customers that act separately from an association do not have high market power, since they do not form agricultural cooperatives in order to push prices downward.

There are several associations in the livestock value chains in Ghana which are scattered all over the country performing different activities (input purchase, production, transportation, processing, storage). In this context Table 10 illustrates detailed information for two national associations.

[31] *Oppong-Anane, K. (2016). Review of the livestock/meat and milk value chains and policy influencing them in Ghana. https://www.fao.org/3/i5264e/i5264e.pdf*

[32] *Garcia, M., Sedi, M., & Willy, D. (2021). BIO4AFRICA - Diversifying revenue in rural Africa through circular, sustainable, and replicable biobased solutions and business models - D1.1: Contexts and needs of African rural communities.*

[33] *D Boafo, N., Kraa, J, J., & Webu, Cl, G. (2018). Porter'S Five Forces Impact on the Performance of Companies in the Banking Industry in Ghana. International Journal of Economics, Commerce and Management United Kingdom.*

Table 10: National dairy and butchers/meat cutters/ small livestock owners association [34]

Name and Membership	Ghana National Dairy Farmers Association; Membership: 200	Ghana co-operative Butchers, Meat cutter and Small scale Livestock Owners Association Ltd; Membership: 53,270
Head office location	Accra; Mayfield House C343/26 No.10 AkoAdjei St. Near Miklin Hotel, East Legon	Gye Nyame Building, Opera Car Park
Address	P.O. Box 7107, Accra North, Ghana Tel: 0243028724 Email: divine.amenuku@yahoo.com	P. O. Box 2100, Mamprobi-Accra Tel: 024-4451471
Aims / Objectives	To bring together all dairy farmers in Ghana; To serve as a forum for dissemination of improved methods of dairy production and marketing; To serve as a link between farmers and the Ministry of Food and Agriculture; To help address members concerns and supply agencies; To source for affordable credit facility for members; Creation of awareness through education and innovation skills; To cater for members welfare in the event of need or disaster; To promote the use of fresh milk and its processed products.	To bring together all local butchers, meat cutters and small scale livestock owners association under one umbrella with one voice to promote their economic interest; To arrange for the supply of livestock to members either through import or from local sources for distribution to various classes of customers.

Over 50 NGOs in Ghana support the livestock value chains with the provision of training on improved management, improved breeds, support vaccinations for disease prevention, micro-credit etc (Table 11). Generally, some NGOs concentrate on society issues and inequality issues, though in Ghana the bargaining power of customers is not strong with small scale farming and livestock operators being unable to form credible and sturdy cooperatives for the acquisition of better input prices. Therefore, profitability of the industry is impaired, though the ability to switch easily to another supplier could alter the bargaining power in remote rural areas.

Table 11: Major NGOs acting in support to the livestock/meat and milk value chains [35]

Name of the organization	Name and position of person of contact	Objectives/activities	Full address of contact
Heifer International, Ghana	Mr. Roland Kanlisi, Country Director	Livestock production and management for poverty reduction	Tel: +233 302 501381
The Hunger Project, Ghana	Mr. Samuel Afranie, Country Director	Ending hunger through advocacy and influence (programs include livestock production as a means to alleviate poverty)	P.M.B. CT7, Cantonments, Accra; Tel: +233 302 544 365 or 502 658

34 Oppong-Anane, 2016; Livestock/Meat and Milk Value Chains Field Data (2013)

[35] Oppong-Anane, 2016; Livestock/Meat and Milk Value Chains Field Data (2013)

Name of the organization	Name and position of person of contact	Objectives/activities	Full address of contact
World Vision International Ghana	Hubert Charles, National Director	Relief, development and advocacy organization (including livestock support services) to overcome poverty and injustice	Tel: +233 202 027 430
Opportunities Industrialization Center	Mr. Sam Debrah, Executive Director	Food Security and Agricultural programs including livestock	P.O. Box AN6241, Accra North; Tel:+233 243328903
Ghana Cooperative Butchers and Small Scale Livestock Owners Association	Alhaji Issifu Dantankwa, Executive Secretary	Livestock Producers Association	Tel: +233 244168065
Ghana National Dairy Farmers Association	Mr. Devine Amenuku, President	Dairy Farmers Association	Tel:+233 243028724
Ghana Feed Millers Association	Mr. M. K. Tawiah, Executive Secretary	Feed producers association	P. O. Box 1746 Accra Tel: +233 302 229253/ +233 277517419

Bargaining power of suppliers

The suppliers are diverse and vary in scope. For example, dairy farmers or chicken breeders differ in qualified personnel, ownership of land, advertising level and of course investment capital. Generally, the power of suppliers to drive prices up is strongly correlated to the quantity of suppliers for all the relevant produce, the differentiation of the product, the strength and control over the market etc. The bargaining power of suppliers is likely to be low in Ghana because market is not dominated by few large suppliers, though there are few substitutes for animal feed (agricultural residues or food residues) pushing price even lower. Suppliers have the power to pressurize the industry through price increases or quality reduction, though customers can also put pressure to suppliers through substitutes or via purchase of huge quantities as cooperatives or associations. In order to understand the bargaining power of potential suppliers, all the relevant input prices should be analysed. In this context,

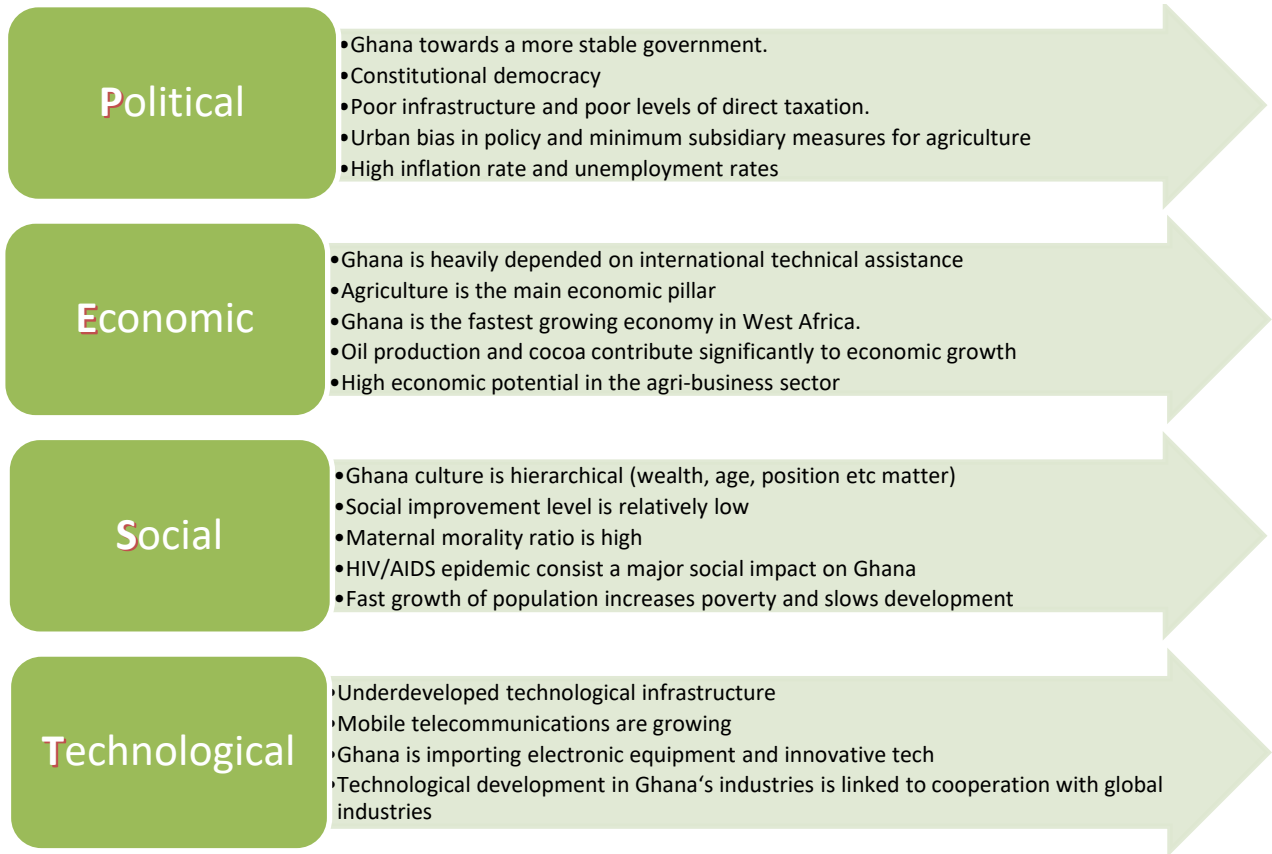
Table 12 depicts the prices of the relevant inputs in relation to livestock breeding in Ghana. Fishmeal and soybean meal are considered expensive, developing a suitable framework for the exploitation of cassava peels for the production of aquaculture feed. Furthermore, the exploitation of local forage species as animal feed could compete directly with mash, soybean meal and white maize, since their prices are considered high. Therefore, the targeted value chain could create a significant asset for new suppliers integrating the proposed animal feed production frameworks.

Table 12: Prices of inputs for livestock production[36]

Type of inputs	Purchase prices
Housing	The cost of livestock housing depends on the design, the kind of materials used, the intended stock numbers and the system of production.
Feed	Sheep & goat mash 50 kg GH¢ 52.5 Pig mash 50 kg GH¢ 49-56 Fishmeal 50 kg GH¢ 95-120 Soybean meal 60 kg GH¢ 80-110 White maize 100kg GH¢ 70-80 Cereal bran 25 kg GH¢ 5-10 Baled rice straw 16 kg GH¢ 3 Cassava peels 35 kg GH¢ 6 Pigeon pea waste 30 kg GH¢ 8 Cotton seed 30 kg GH¢ 20
Water	Dam, dugout, borehole, potable: Cost not available
Veterinary drugs Vaccines	Prices vary widely depending on the type and percentage of active ingredient

[36] *Oppong-Anane, 2016;Livestock/Meat and Milk Value Chains Field Data (2013); US$1.00 = GH¢ 1.96*

PEST analysis



Trends, growth prospects & potential socio-economic impact.

Although Ghana is one of fastest growing countries in Africa, growth rates in relation to technological advancements, political-legal framework and economic development are quite slow. The gap between the stated rate of growth and actual achieved one is significant. Ghana's exports through cocoa, coffee, palm oil, gold and bauxite contribute importantly to the GDP, but the other sectors are still underdeveloped. Therefore, the labour force is underqualified with limited skills and the value chains described will face the same slow growth rate of the economy.

Moreover, inequality in society, infrastructural gaps and inefficiency in agricultural production weaken and hide the abundance of natural resources and pose a significant social boundary for economic growth. On the other hand, movements, and collaborations of the local stakeholders with foreign entities (universities, development programs etc) improve the standards of international trading and promote social equity in the country. The agriculture sector has an assortment of potential and the value chains developed today could create new collaborations, innovation enterprises and make the country more attractive for new investments.

The establishment of bio-based industries exploiting local forage species and agricultural residues tailors to the needs of lower-income agricultural households. All the relevant activities will enable the production of low-cost animal feed and soil amendments from agricultural and pastoral residues of the farmers, integrating a positive impact to the local economies and to the agricultural GDP. Furthermore, the project will play a

significant role in gender inequality issues in the country, since women have a predominant role on household decisions and are usually the main interest by national scheme programs for loan and credit aids. In this context, female engagement is expected to raise, since the project will ensure that women are not left out of the decision-making process.

3.2 Uganda

3.2.1 Value chains definition

In Uganda, BIO4AFRICA will target to test technologies for processing local forage species and manure to produce green biorefinery streams and biochar. In Table 13, the identified product- market combinations of BIO4AFRICA in Uganda are being presented, along with the corresponding feedstocks and technologies.

Table 13: Product- market combinations in Uganda

Product	Market	Feedstocks	Technology
Press cake to be used as animal feed for ruminants	Agricultural sector	Local forage species	Green biorefinery
Protein concentrate to be used as animal feed for pigs whey to be used as animal feed for piglets	Agricultural sector	Local forage species	Green biorefinery
Protein concentrate to be used as animal feed for poultry	Agricultural sector	Local forage species	Green biorefinery
Biochar to be used as soil amendment	Agricultural sector	Manure, struvite	HTC
Biomass briquettes to be used as animal feed	Agricultural sector	Local biomass species	Briquetting

BIO4AFRICA technologies and technology combinations in Uganda

In Uganda, a **small-scale green biorefinery technology** will be tested exploiting protein rich leguminous plants (e.g. Kalliandra, Tithuania, Blabla, Alfalfa, Mucuna beans, Butterfly Pea-Clitoria Ternate, Lablab, Apios Americana) and local Napier elephant grasses. All the above-mentioned species will be processed in fibre/protein grass press cake, protein concentrate and protein whey and the process will be continuously optimised to maximise the extractable protein per ha, while minimising its energy requirements. Furthermore, **Hydrothermal Carbonization Technology (HTC)** will be tested in real life conditions in order to produce biochar. The biorefinery unit will be combined with the small-scale HTC unit to produce biochar by manure produced in participating cattle farms and by the deproteinized whey stream of the biorefinery. Biochar produced via HTC will be assessed for use as soil conditioner. Finally, the pilot case will also test a suitable **densification technology (briquetting)** on press cake resulting from the green biorefinery and other local biomasses, with a view to increasing products density, as well as to reducing the environmental impact and cost of transportation.

Animal feed as a) Press cake for ruminants, b) protein concentrate for pigs and poultry, c) whey as animal feed for pigs

Specific outputs as **animal feed** will be (i) fibre/protein grass press cake as optimized ruminants feed; (ii) Protein concentrate as monogastrics feed (pigs, poultry); (iii) Protein whey as monogastrics feed (pigs). Protein rich leguminous plants (Kalliandra, Tithuania, Blabla, Alfalfa, Mucuna beans, Butterfly Pea-Clitoria Ternatea, Lablab, Apios Americana), local Napier elephant grasses and cassava leaves will be processed in

fibre/protein grass press cake, protein concentrate and whey. The 3 most promising leguminous crops in terms of protein and moisture content will be selected to be grown by local farmers in Uganda. The fibre-rich protein press cake resulting from the biorefinery will be used as animal feed for cows from local farmers and press cake briquettes will be produced to facilitate transportation and storage. The precipitated protein concentrate output stream will be transported to pig and poultry farmers to be assessed as animal feed. Cattle feed trials, pig feed trials and piglet trials will be performed in order to evaluate the potential of the relevant products of the Ugandan pilot case.

Biochar as a soil amendment

Biochar produced via HTC will be assessed for use as soil conditioner in Uganda. Biochar produced this way will be assessed for its use as a soil conditioner, along with manure and struvite, imported from Netherlands for the scope of the project. The environmental benefits through the use of alternative protein sources for animal feed instead of the threatened to extinction silver fish, local production of protein and nutrient circularity via the return on land of nitrogen and other minerals in the form of biochar, struvite and soil improvement manure will be validated as a whole for the BIO4AFRICA project.

3.2.2 Market structure analysis

Target markets and size (per product/ per country)

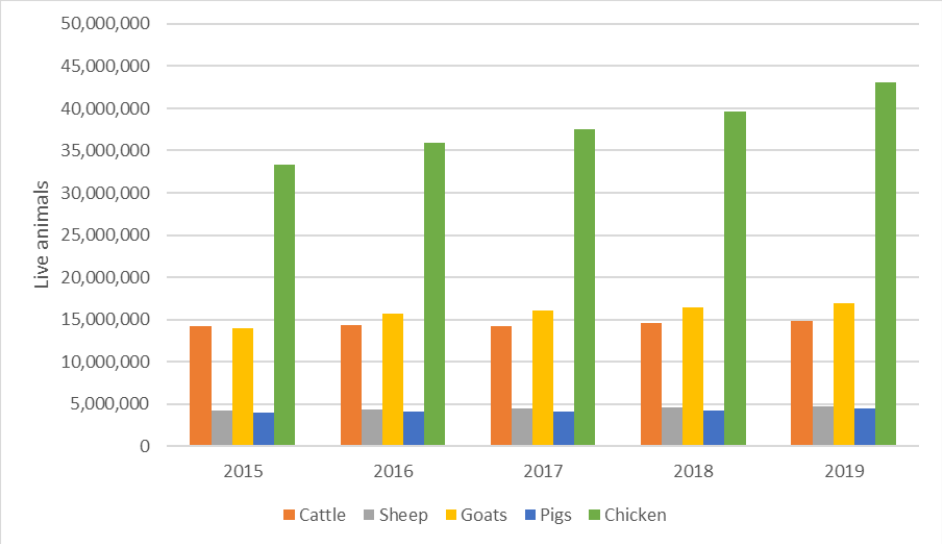
Despite the pandemic's impacts, Uganda is expected to face one of the highest economic growth rates in 2021 of 6.3%, in comparison with other African countries. As of 2020, Uganda registered 24.03%, as contribution of the agricultural sector to the GDP, meaning that the primary sector is a key element for the Ugandan economy. Most of the population income in Ghana comes from farming activities (60.0% of the total income), while the second most important income comes from non-agricultural wages and self-employment accounting 29.0% of the total population income[37].

Target groups of the Ugandan market considering the unique characteristic of the area are: farmer operators, businesses, agri-entrepreneurs, supporting organizations and government bodies. The farmer operators are mainly devoted to the activities of farming and processing of agricultural products, while other popular activities are linked to the exploitation of livestock resources, specifically dairy goats, and meat goats[1]. Livestock is a very an important factor for many families in the country, in order to optimize income, improve social status and contribute to food security. The main breeding animals in Uganda are highlighted in

[37] *Garcia, M., Sedi, M., & Willy, D. (2021). BIO4AFRICA - Diversifying revenue in rural Africa through circular, sustainable, and replicable biobased solutions and business models - D1.1: Contexts and needs of African rural communities.*

Figure 7

Figure 7: Relationships among stakeholders for Plantain-cotton value web in Ghana[38]



The agricultural production mix of Uganda includes an assortment of crops mainly for home consumption, though exports have increased by 20% between 2018 and 2019. Considering Table 14, maize, bananas, beans, potatoes and cassava have a high potential for further development, while banana production recorded the highest increase between 2018-2019 (19%).

Table 14: Agricultural production mix of Uganda, 2020[39]

Crops	2015	2016	2017	2018	2019
Plantain Bananas and other cereals	4,623.37	4,031	4,803	6,989	8,326
Millet	236.48	226	256	287	196
Maize	2,647.50	2,662	2,767	3,442	5,000
Sorghum	410.72	329	453	543	211
Rice	238.19	237	272	199	255
Sub-Total	**3532.89**	**3,455**	**3,747**	**4,471**	**5,662**
Root Crops					
S/potatoes	2,045.14	2,003	2,373	1,484	1,485
Irish Potatoes	177.09	171	204	327	326
Cassava	2,983.19	3,023	3,285	4,390	6,983
Sub-Total	**5,205.42**	**5,197**	**5,862**	**6,202**	**8,794**
Pulses					
Beans	1,012.46	1,008	1,154	728	627
Vegetable oil crops					
Ground nuts	295.897	283	312	253	302
Soya Beans	28.013	26	40	108	117

[38] *MAAIF. (2020). Ministry of Agriculture Animal Industry and Fisheries - Statistical abstract 2019/2020. https://nfass.agriculture.go.ug/Home/Download/9*

[39] *MAAIF. (2020). Ministry of Agriculture Animal Industry and Fisheries - Statistical abstract 2019/2020. https://nfass.agriculture.go.ug/Home/Download/9*

Crops	2015	2016	2017	2018	2019
Sim sim	145.127	144	173	196	247
Sun flower	244.647	235.89	293.58	372.08	383.2
Oil Palm	92.2	106.9	98.3	150.5	162.3
Sub-Total	**805.884**	**796**	**918**	**929**	**1,212**
Total	**15,180.02**	**14,487**	**16,485**	**19,319**	**24,621**

Regarding the three selected forage species, the availability varies based on several aspects, though there are patterns in relation to the availability and fluctuation of productivity for each one. Mucuna: Readily available and common in most parts of Uganda. Its growth is however restricted to the wet season since it dies at the onset of the dry season. Alfalfa: Available in selected parts of the country, mainly central Uganda. It is adapted to grow in a wide variety of environments and can tolerate dry periods to still give a good yield. Tithonia: Available in most parts of Uganda especially in grasslands, roadsides, degraded land and riparian zones. Its productivity rarely fluctuates since it is considered to be a competitive weed that can compete with crop plants and shade out native vegetation.

Value chains SWOT analysis

Strengths	Weaknesses
All outputs Low capital and operating costs for the Green biorefinery and HTC units Low complexity technologies, not requiring high level of knowledge and skills (Briquetting) Innovative, environmentally friendly outputs Availability of cheap raw materials with practical indigenous knowledge on local species by the local farmers and stakeholders, cheap overheads (transportation costs the processed products etc) **Biochar for soil improvement** Improved soil fertility, especially for sandy soils Increased crop yield Reduced nutrient loss Low-cost in comparison with the alternatives Indirect reduction of other greenhouse gases through soil emissions **Animal feed in various forms** High availability of alternatives during the season Increased nutrient concentration Different types of animal feed for manifold species (ruminants, pigs and poultry)	**All outputs** Low impact of distribution channels since farmers tend to work independently Limited access to information, communication and learning mechanisms Capacity building and dissemination are required especially for the green biorefinery and HTC units **Biochar for soil improvement** Alternatives with an established trade network, dominated by major international trade businesses Education of farmers to enhance adoption is required Effectiveness of biochar use as soil amendment is highly dependent on biochar synthesis, soil and crop types and quantities applied. **Animal feed in various forms** Availability and fluctuation of forage species is highly dependent on rainfall seasons Old management practices are a part of tradition
Opportunities	**Threats**
Business opportunities for local agrochemical providers and intermediaries Development of new needs for products and substitutes Generation of increased demand due to low selling price of the new products, which is important for low-income farmers The market for biochar is expanding Green biorefinery and HTC units could create an assortment of new job opportunities	Potential negative health impacts of handling biochar Low adoption from the local population Elephant grass is already considered as an alternative animal feed Potential low acceptability of the technology by the rural populations who are usually very conservative in Uganda. Inadequate after sales service

Customers, customer segments and their needs

The National Food and Agricultural Statistics System (NFASS) Database of Uganda reports that 103,970 households (66%) raise animals for food, materials, etc, including Cattle, Goats, Pigs, Poultry, Rabbits and Dogs. Therefore, the market size for animal feed is illustrated in Table 15, highlighting the number of households breeding of the related animals per district in Uganda.

Table 15: Households breeding livestock per district[40]

District	Cattle	Goats	Sheep	Pigs	Poultry	Rabbits	Dogs
Kalungu	6,815	8,275	1,092	10,501	14,868	614	1,912
Iganga	9,024	8,615	501	1,200	14,399	245	796
Nebbi	5,037	18,769	1,706	2,929	18,694	340	3881
Amuru	4,039	9,743	1,599	2,884	12,709	115	4,634
Ntungamo	9,668	21,820	3,563	11,048	18,835	2,917	6,955
Total	**34,583**	**67,222**	**8,461**	**28,562**	**79,505**	**4,231**	**18,178**

Therefore, the market size for animal feed is considered adequate, especially in the districts of Iganga, Nebbi and Ntungamo for cattle, goats and poultry. In relation to the value chain for biochar as soil amendment, the most popular crops grown in Uganda are Legumes (beans, field beans etc), Wheat, Rice, Maize, Oil seeds (Groundnuts, Soyabeans, Sunflower, Simsim, OilPalm), Vegetables (Cabbages, Tomatoes, etc), Tree Crops (Coffee, Cocoa, Tea, Cashew Nuts), cassava, sweet potatoes, cotton, plantain and fruits. In terms of fertilization, most of the farmers claimed to be using organic fertilizers, specifically for animal droppings and manure, while some of them use liquid organic fertilizers. Nevertheless, most of the farming households (89.5%) employed with crop production are mainly for subsistence farming, while only 10.5% earns income from crop production[1]. In Table 16 the percentage of households growing different types of crops is illustrated for 2020.

Table 16: Share of households growing different Crops Categories per district[41]

District	Cereals	Leguminous	Oil seeds & Palm	Vegetables	Root Tubers	Fruits	Plantains	Tree Crops
Kalungu	88.1	84.8	42.0	21.8	79.9	17.1	79.9	73.3
Iganga	86.4	65.1	54.8	29.2	69.2	9.9	40.7	32.1
Nebbi	80.8	49.2	44.8	47.7	96.7	11.1	17.8	14.9
Amuru	90.8	75.1	63.1	23.1	80.3	16.3	15.0	0.9
Ntungamo	79.9	92.2	53.4	32.0	78.7	23.7	93.3	64.9
Total	**83.8**	**75.9**	**51.3**	**32.0**	**81.1**	**17.0**	**58.3**	**43.3**

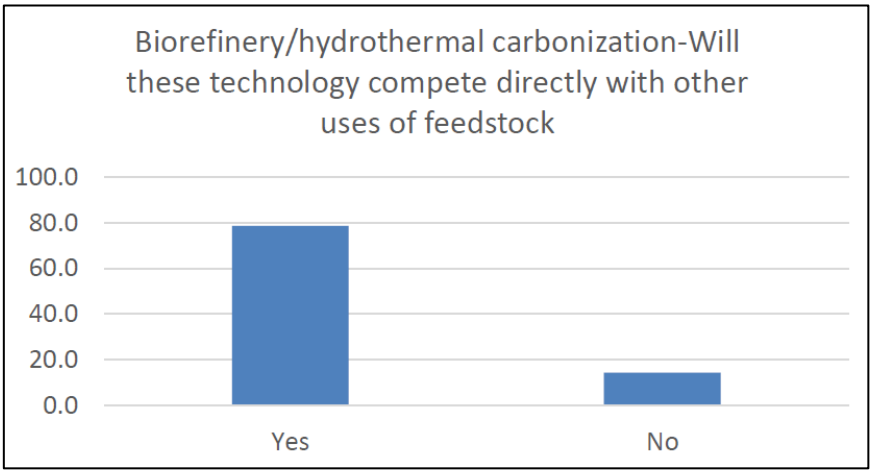
[40] *NFASS. (2020). THE REPUBLIC OF UGANDA MINISTRY OF AGRICULTURE, ANIMAL INDUSTRY & FISHERIES FARMER REGISTRATION REPORT. https://nfass.agriculture.go.ug/Home/Download/2*

[41] *NFASS. (2020). THE REPUBLIC OF UGANDA MINISTRY OF AGRICULTURE, ANIMAL INDUSTRY & FISHERIES FARMER REGISTRATION REPORT. https://nfass.agriculture.go.ug/Home/Download/2*

Level of competitiveness

In Uganda, 70 % of the participants in research of Task 1.4 indicated that the technologies would compete directly with other uses of the feedstocks with less than 20% disagreeing on competing with other uses of the feedstocks.

Figure 8: Competition with other uses of the feedstocks[42]



In Uganda knowledge on techniques such as briquetting, pyrolysis and anaerobic digestion is considered adequate. The acceptance on the potential adoption of bio-based approaches within the farm operative is widely accepted and positively perceived if this comes with a high-quality price ratio to face initial investment in machinery and training of workforce.

Competing uses for the forage species vary based mainly on the characteristics of every crop. Mucuna: it is used as a cover crop hence farmers tend to use it when they apply conservative techniques in crop production; Its Nitrogen fixing characteristics allows it to be used as green manure; Also used for human consumption after reducing its toxicity; Its high crude protein content (about 26% CP) is used as supplementary feed source to replace commercial supplements in compounding home-made rations. Alfalfa: Leafy vegetables; Cover crop for conservation agriculture and fertilizer. Elephant grass: Prevention of soil erosion hence also used for soil fertility improvement; pest management; hedge/fencing; roofing; making handicrafts; bio-fuel production. Tithonia: Ornamental plant; green manure and also used as medicine

Potential collaborators

Renewable feedstocks and by-products that can be exploited to create value-added commercial opportunities and potential collaborations with BIO4AFRICA pilot cases include[43]:

- Use legume leaves for food preparation.
- Use legume husks as animal feed to semi-intensive livestock farming or on the spot.
- Process legume residues for fibres/protein grass press cake pellets.

[42] *Sedi, M., Kyalo, W. D., & Marechera, G. (2021). Diversifying revenue in rural Africa through circular, sustainable and replicable biobased solutions and business models - D1.4: Co-definition of technologies to be transferred with local farmers and communities.*
[43] *Anastasiadis, F., Skourtanioti, E., & Kosmidis, V. (2021). BIO4AFRICA - Diversifying revenue in rural Africa through circular, sustainable and replicable biobased solutions and business models - D1.2: Mapping of local forage agri-food systems.*

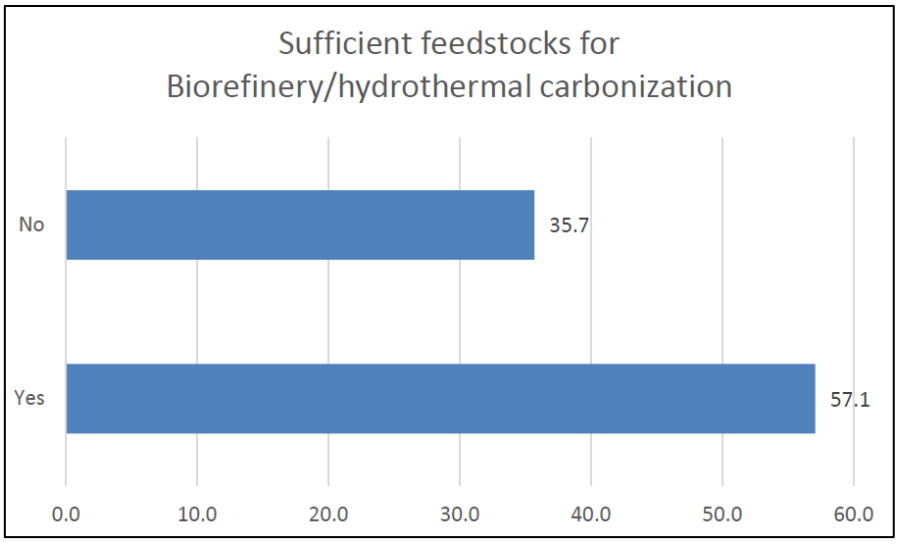
- Collect and use legume milling by-products (e.g., husk) as organic input on farms
- Use of cassava leaves as animal feed (e.g., for cattle, poultry, goats, sheep).
- Use of cassava processing by-products (e.g., dry peels, tubers) as animal feed (e.g., for pigs).
- Export of cassava starch in the paper industry as a binding agent in pulp production to create higher-value paper.
- Export of cassava starch as an agent in the textile industry for producing better quality and resistant printed fabric.
- Export of cassava starch for food industry applications, e.g., thickener, binder, expanding agent, stabilizer, carrier of sweetener and condiment.
- Export of cassava starch for application in the beverages industry, e.g., sweetener.
- Export of cassava starch for candy production purposes, e.g., gelatinize, thickening, enhance foam, control crystallization, and enhance candy gloss.

3.2.3 Market conduct analysis

Competitive rivalry within the market

In Uganda, as revealed by BIO4AFRICA Task 1.4 activities, farm managers (mainly male farm operators, in charge of leading the decision-making process in farming daily operations) have used techniques such as briquetting, pyrolysis and anaerobic digestion in the past. Over 57.1 % of the stakeholders noted that there are sufficient feedstocks for the biorefinery and hydrothermal carbonisation technologies in Uganda with 35.7 % indicating limited feedstocks to support the same.

Figure 9: Perception whether there are sufficient feed stocks for bio-refinery /Hydrothermal carbonization[44]



[44] *Sedi, M., Kyalo, W. D., & Marechera, G. (2021). Diversifying revenue in rural Africa through circular, sustainable and replicable biobased solutions and business models - D1.4: Co-definition of technologies to be transferred with local farmers and communities.*

The threat of new market entrants

Among the limiting factors with the highest rank, the lack of credit (e.g., loans, other financial instruments) and lack of financial capital were considered determinant by 75% of respondents, having a negative impact on barriers and challenges in their daily operations; followed by low selling prices, considered as important by 67% of respondents. Among the limiting factors with the highest rank, the lack of collateral, access to agricultural mechanization services and lack of land access were considered determinants by 65%, 38% and 38% of respondents respectively, having a negative impact on barriers and challenges in the future maintenance and sustainability of their activities.

Based on the above-mentioned, the lack of direct (cash, vouchers towards the purchase of agricultural inputs, interest-free loans, among others) and indirect (tax breaks, fuel, seeds, fertilizers) government subsidies were key factors considered as very relevant, thus formulating a threatening scheme for new market entrants. Other limiting factors for domestic investors are lack of education and training access, lack of awareness among policymakers regarding use of bio-based solutions (technologies and techniques/processes to produce goods coming from renewable biogenic material) and trust in government. On the other hand, Venture Capitals and NGOs from other countries could develop the appropriate conditions for new market entrants.

Economic relationships within markets

In Uganda, in Task 1.4 activities of BIO4AFRICA, the stakeholders agreed to the fact that bio-based technology could spur economic development, agreeing at the same time to another aspect linking bio-based innovations with new types of employment and provision of alternative crop by products[45]. The participants of the same survey stated that more Government support is needed to promote the technology, continuous sensitization to be done and promote group farming to benefit from economies of scale.

The pilot case in Uganda could have a significant economic, environmental and social benefit for smallholder dairy farmers, as well as for the pigs and poultry industry, by offering the opportunity for on-farm production of rich proteinaceous animal feed by utilizing local crops and grasses instead of imported soy. As both the press cake and dried protein concentrate are storable and easily transportable feed products, this contributes to feed availability throughout the year even in locations with less favourable growing conditions and makes it possible to bring animal feed to zero-grazing small dairy farmers near urban areas (like Kampala) where is a shortage of dairy cattle feed, in particular in the dry season.

Patterns of commercial behaviour

Commercial behaviour in Uganda has specific patterns strongly connected to the mannerism of local communities, but also connected to the perspective of stakeholders. In this context, it is necessary to conduct

[45] *Sedi, M., Kyalo, W. D., & Marechera, G. (2021). Diversifying revenue in rural Africa through circular, sustainable and replicable biobased solutions and business models - D1.4: Co-definition of technologies to be transferred with local farmers and communities.*

continuous sensitization of communities on the technologies, train enough manpower to run the plants and ensure accessibility of the machine's spare parts in the local market.

In activities conducted under Task 1.4 of BIO4AFRICA, stakeholders from Uganda agreed that that the proposed bio-based technologies fit well among the Community and that the technology empowers more women than other gender groups with male and youth being empowered than the other gender groups rated neutral. Furthermore, the majority of the respondents have stated that women are less busy than the males hence will allocate more time into the technology. Others indicated on the need for continuous sensitization of community members to partake the technology and encourage more youths to take part in agriculture.

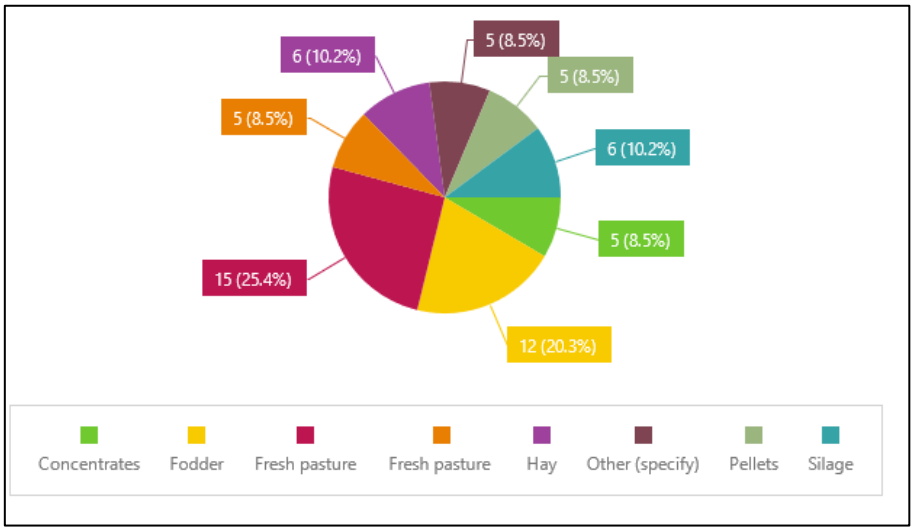
Regarding economic limiting factors, 100% of female respondents of survey conducted under Task 1.1 of BIO4AFRICA[46] manifested a high degree of correlation between low salaries, lack of access to credit and the fact of being a woman operating in the field.

3.2.4 Market performance analysis

Bargaining power of customers

Customers for press cake, protein concentrate and fresh biomass briquets used as animal feed are mainly households using processed feeds. Forage species prices are determined by farmers' (customers') preference, by the potential benefits of the forage species, by the availability and by the time of season. It is possible to store these forage species as hay/silage and use them during the dry season limiting price fluctuations, however there is still limited knowledge and skills in forage production and preservation in the country. In this context, the shares of different types of animal feeds used in Uganda is illustrated in Figure 10. Moreover, in Figure 11 the shares of different animal feeds per district are highlighted in a bar chart as well.

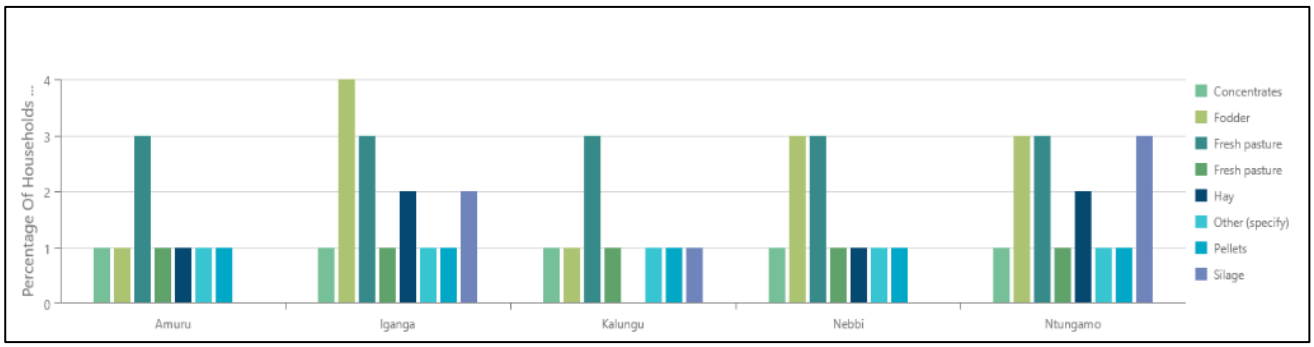
Figure 10: Shares of animal feed types in Uganda in total[47]



[46] *Garcia, M., Sedi, M., & Willy, D. (2021). BIO4AFRICA - Diversifying revenue in rural Africa through circular, sustainable, and replicable biobased solutions and business models - D1.1: Contexts and needs of African rural communities.*

[47] *NFASS (Available from: https://nfass.agriculture.go.ug/BI/ReportPreviews)*

Figure 11: Shares of animal feed types in Uganda per district[48]



It is obvious that concentrates, fodder, pellets and silage represent about half (47.5%) of the total processed/unprocessed animal feed used in Uganda. Therefore, there is a gap in the customer market for the proposed products especially in Iganga, Ntungamo and Nebbi. Furthermore, the number of large-scale livestock farmers is considerably small, which is illustrated via the 18 and the 4 large-scale livestock farmers located in Kalungu and Ntungamo respectively, lowering the bargaining power of customers in Uganda, as shown in Table 17. Most of the livestock farms in Uganda are small, managing little bargaining power, with milk production being the major activity for livestock farmers.

Table 17: Number of large-scale livestock farmers by district and sex[49]

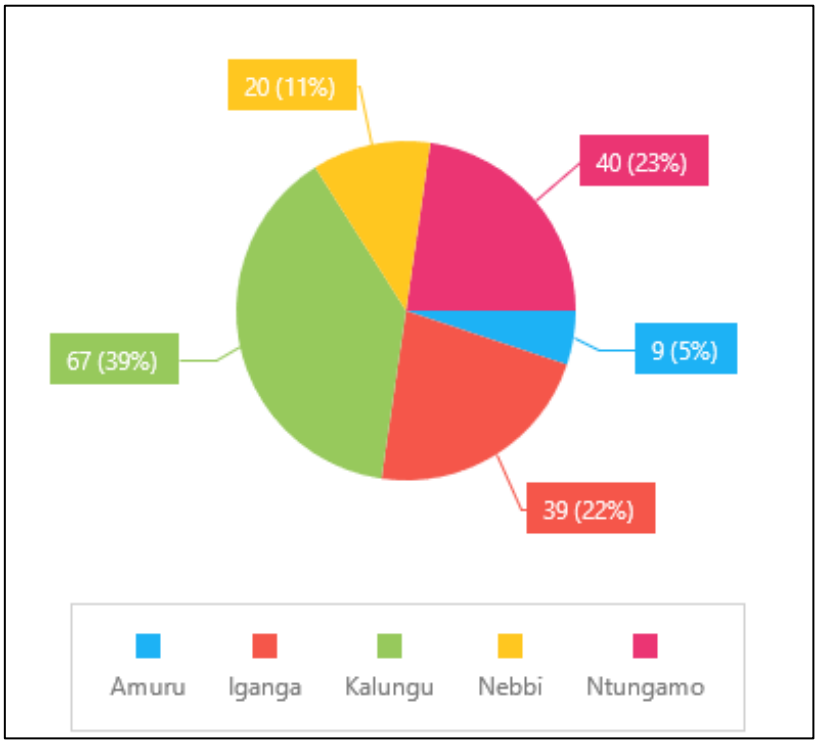
Districts	Female	Male	Grand Total
Kalungu	4	14	18
Ntungamo		4	4
Grand Total	4	18	22

In relation to Biochar as soil amendment, Kalungu, Ntungamo and Iganga are the districts using more organic fertilizers in comparison with the others (

[48] *NFASS (Available from: https://nfass.agriculture.go.ug/BI/ReportPreviews)*
49 NFASS (Available from: https://nfass.agriculture.go.ug/BI/ReportPreviews)

Figure 12). Therefore, the proposed biochar by product to be used as soil amendment using plant residues should focus on these districts, which highlight high usage of organic fertilizers.

Figure 12: Proportion of households using organic fertilizers by district[50]



Bargaining power of suppliers

In Uganda, the survey of *Gilligan et al.*[51] indicated that women play a significant role in crop selection (specifically for food crops), hence the bargaining power of household farms supplying the raw materials is strongly affected by the decision-making of women. Moreover, access to market information via local FM radio stations improves to a significant degree the bargaining power of farmers in relation to prices on surplus production[52] (15% higher farm-gate price). Lack of credit is considered as a very important issue for Ugandan farmers (as stated above), thus the bargaining power of suppliers is diminished. The lower bargaining power is explained by *Courtois & Subervie*[53], since farmers are more likely to produce higher yields, to store produce in optimum conditions and to wait for prices' increase due to demand and supply, if they have access to credit options. Furthermore, subsidized inputs are a form of credit for Ugandan farmers and in this context, 23.6% of farm households received free or subsidized inputs by the government, local shops and politicians as shown in

[50] *NFASS (Available from: https://nfass.agriculture.go.ug/BI/ReportPreviews)*

[51] *Gilligan, D. O., Kumar, N., McNiven, S., Meenakshi, J. V., & Quisumbing, A. (2020). Bargaining power, decision making, and biofortification: The role of gender in adoption of orange sweet potato in Uganda. Food Policy. https://doi.org/10.1016/j.foodpol.2020.101909*

[52] *Svensson, J., & Yanagizawa, D. (2009). Getting prices right: The impact of the market information service in Uganda. Journal of the European Economic Association. https://doi.org/10.1162/JEEA.2009.7.2-3.435*

[53] *Courtois, P., & Subervie, J. (2014). Farmer bargaining power and market information services. American Journal of Agricultural Economics. https://doi.org/10.1093/ajae/aau051*

Table 18.

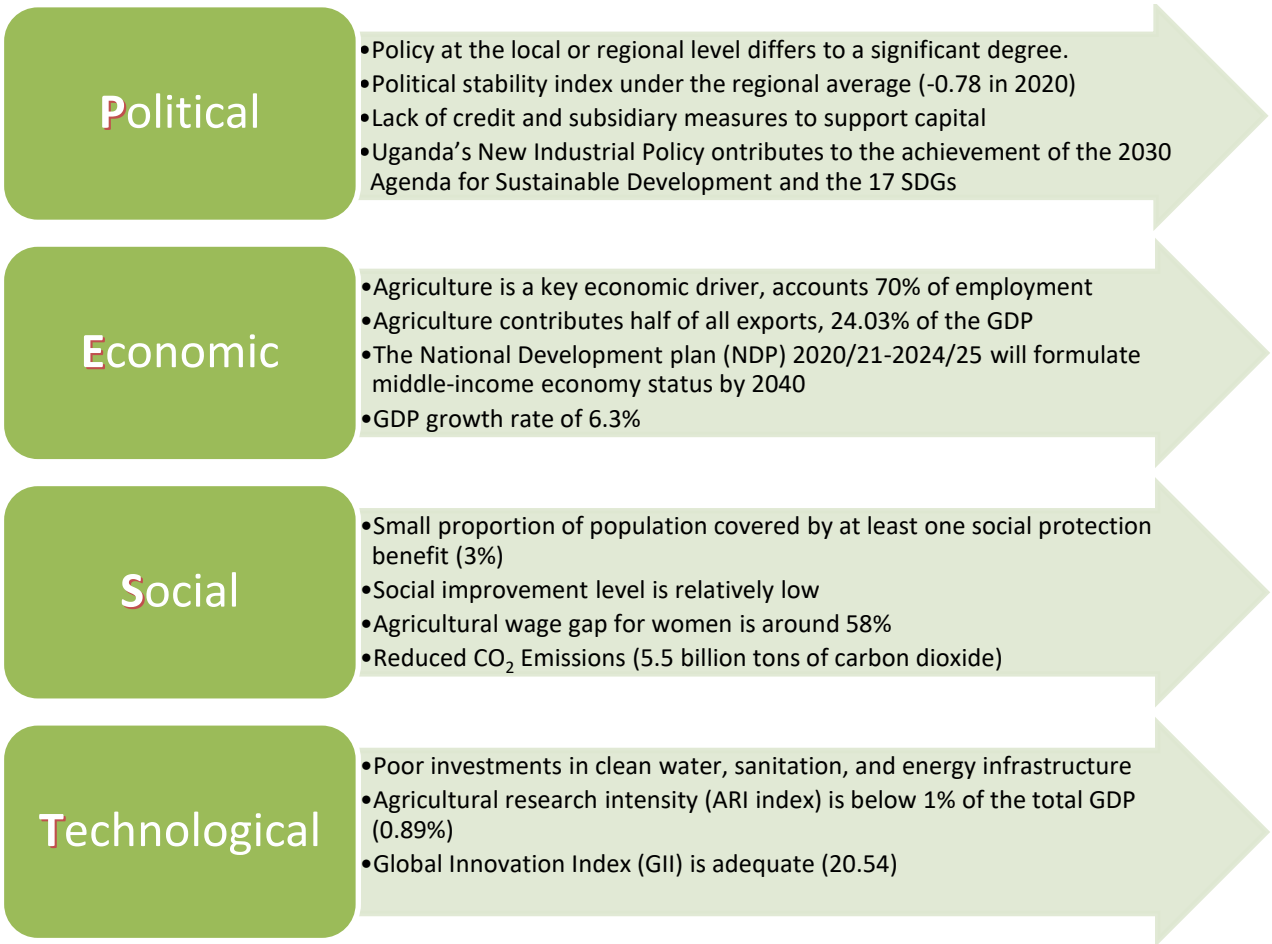
Table 18: Source of inputs in Uganda (Percentages)

Districts	Received free input		Source of inputs					
	Yes	No	MAAIF	Cooperatives	NGOs	Shop/ Local	Politicians	Other
Kalungu	43.5	56.6	84.3	0.9	0.7	10.5	3.4	0.2
Iganga	21.0	79.0	81.1	1.7	4.2	12.1	0.9	0.1
Nebbi	16.6	83.4	75.1	0.7	1.5	13.5	0.9	8.4
Amuru	9.5	90.5	48.8	3.1	6.6	36.6	2.9	2.0
Ntungamo	24.5	75.5	81.1	1.4	0.5	12.9	3.6	0.5
Total	23.6	76.4	80.3	1.3	1.5	13.0	2.8	1.2

Source: NFASS, 2020

According to the Farmer Registration Report from the Ministry of Agriculture, animal industry and fisheries in Uganda, 6% of the households reported some form of access to agriculture credit, while NGOs and cooperatives do not contribute notably to free or subsidized inputs, thus lowering the dependence of farmers to cooperatives and associations. Most forage species are traded among households with alfalfa being the major forage where merchants are mainly small traders. Distribution channels are restricted Through Government agencies NAGRIC, NARLI, NAADS, Research centers, but also through Agricultural Shows and exhibitions. Furthermore, there are vets that purchase forage species from medium- and large-scale producers and directly deliver the forage to small farmers. Based on the abovementioned, the bargaining power of farmers is considered weak, needing a boost of governmental subsidiary measures and the formulation of a cooperative strategy in order to strengthen its potential.

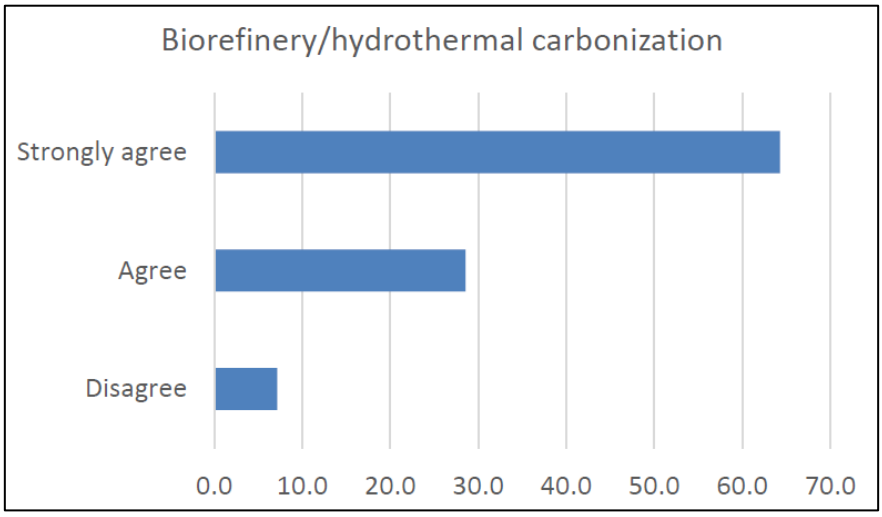
PEST analysis



Trends, growth prospects & potential socio-economic impact.

In Uganda, most of the participants (90%) in the research for the "Co-definition of technologies transferred with local farmers and communities" indicated to strongly agree and/or agree that the proposed technologies are environmentally friendly with a few (less than 10%) disagreeing. The recommendations given were to conduct environmental audits, community sensitization on environmental impact associated with the technology and have policies enacted by Government to protect the environment.

Figure 13: Perception on whether the proposed technology is environmentally friendly[54].



Furthermore, smallholder dairy farmers in urbanised areas are mainly women and BIO4AFRICA's bio-based solutions will also contribute to the improvement of socio-economic position of women and their families, helping them grow out of poverty. The diversification of products in farm level will increase economic options for farmers within the feed value chain, making stronger the local rural employment and green entrepreneurship.

[54] *Sedi, M., Kyalo, W. D., & Marechera, G. (2021). Diversifying revenue in rural Africa through circular, sustainable and replicable biobased solutions and business models - D1.4: Co-definition of technologies to be transferred with local farmers and communities.*

3.3 Cote D' Ivoire

3.3.1 Value chains definition

In Cote D' Ivoire, BIO4AFRICA will target to test technologies for processing various types of local agri-food and forest waste streams to biochar, raw biomass pellets, bioplastics, and bio-composites. In Table 19, the identified product- market combinations of BIO4AFRICA in Cote D' Ivoire are being presented, along with the corresponding feedstocks and technologies.

Table 19: BIO4AFRICA product- market combinations in Cote D' Ivoire

Product	Market	Feedstocks	Technology
Biochar powder for additive in water filtration systems	Water purification market Agricultural market	Cassava peelings, rice husk, small branches, thinning woods, and/or residues of wood processing	Pyrolysis
Biochar powder for soil amendment	Agricultural market		Pyrolysis
Raw biomass pellets for animal feed (poultry, guinea fowl, pigs)	Livestock market	Rubber seed, cashew nuts, soybeans, rubber seed	Pelletizing
Bio-composites for composite panels	Construction industry	Bioplastics, vegetable fibres (roast tree fiber, cocoa pods)	Bio-composites production process
Bioplastics for packaging industry	Packaging industry Agricultural market	Cashew apple juice	Bioplastics production process

BIO4AFRICA technologies and technology combinations in Cote D' Ivoire

In Cote D' Ivoire, a **community level pyrolysis system and a traditional pyrolysis oven** will be adapted and tested in order to produce biochar powder from major agricultural by-products (Cassava peelings, rice husk, forest-based by-products etc.). Various feedstock blends and pyrolysis operating parameters will be defined and tested, depending on the availability of feedstocks, and intended final use of biochar to be produced (soil amendment, additive in water filtration systems). Any necessary pretreatment steps required (i.e. torrefaction, pressing) for crop residues to be used as feedstocks will be assessed and optimized during the

pilot phase implementation. Additionally, a **pelletization line** will be tested, to produce raw biomass pellets to be used as animal feed from commonly found agricultural waste. Finally, a simple, low-cost production process of bio composites from local vegetable and other agricultural waste and bioplastics will be developed. The production of bioplastics will be achieved through an existing process of producing PLA from cashew apples that will be optimized in the context of BIO4AFRICA activities.

Biochar as a soil amendment

In Cote D' Ivoire, biochar will be tested as a soil amendment maize and tomato crops. The benefits of adding biochar to soil are described in page 69.

Biochar as pollutants adsorbent in water filtration systems

Regarding the use of biochar as pollutants adsorbent, a strong evidence base suggests that biochar has excellent capacity to remove a broad spectrum of contaminants from aqueous systems including toxic inorganics (e.g., uranium, fluoride, arsenic), radionuclides, synthetic and emerging organics such as pesticides and pharmaceuticals, and pathogenic organisms[48]. This points to the potential of using biochar as adsorbent in water filters for removal of multi-contaminants in drinking water, with several advantages over other low-cost methods (sand filtration, boiling, chlorination etc). However, the link remains not fully elucidated between materials used, process conditions and performances, that are dependent on the pollutants to be removed and the water matrix. We will explore factors such as biochar porosity, size of pores, role of functional groups presents on surface and material acidity to advance these biochar applications.

Raw biomass pellets as solid fuel

Biomass pellets will be produced in BIO4AFRICA pilot case in Cote D' Ivoire to be used as animal feed. Pelletization allows better conservation of feed resources, reduces feed wastage by animals, improves animal digestibility and zootechnical performance. Additionally, as volumes are reduced, transport and storage requirements are decreased. The parameters influencing the manufacture of pellets are: the moisture content, the physico-chemical composition of the feedstocks used, the pressure and the temperature and all of them will be tested and optimized in the BIO4AFRICA pilot case in Cote D' Ivoire.

Bio-composites for construction materials

Bioplastics, vegetable fibers (roast tree fiber, cocoa pods) and other lignocellulosic fibrous agricultural waste will be mixed with resin/ binding agents and hot pressed at a small-scale prototype that will be developed for BIO4AFRICA, in order to produce bio-composites in the form of panels. These fibrous panels will be lightweight with several potential non-structural load bearing indoor applications (false ceiling, furniture, interior walls, insulation etc.).

Bioplastics

A process to obtain bioplastics from cashew apple juice and molasses in a process of microbiological fermentation to obtain PHA, already developed by INP-HB, will be engaged in BIO4AFRICA pilot case in Cote D' Ivoire to produce PHAs. These PHAs were then isolated in powder form and used for the formulation of composite materials.

3.3.2 Market structure analysis

Target markets and size (per product/ per country)

a) Agricultural sector in Cote D' Ivoire

Agriculture plays a leading role in Cote D' Ivoire economy being the engine of economic growth, accounting for 16% of GDP and employing two-thirds of the population[55].Cote D' Ivoire is the world leader producer in cocoa, cashew nuts and rubber and a net exporter of other major cash crops including coffee, cotton, palm oil and bananas. Poverty is estimated to have surged from 10% in 1985 to 46% in 2015, remaining higher in rural areas. About 15% of rural households are vulnerable to food insecurity, and rural women and youth are the most vulnerable. Farming, livestock, and fishing together employ close to 46% of the active population and provide the main source of income for two-thirds of households.[56]

Table 20: Agricultural production statistics in Cote D' Ivoire (year: 2018)[57]

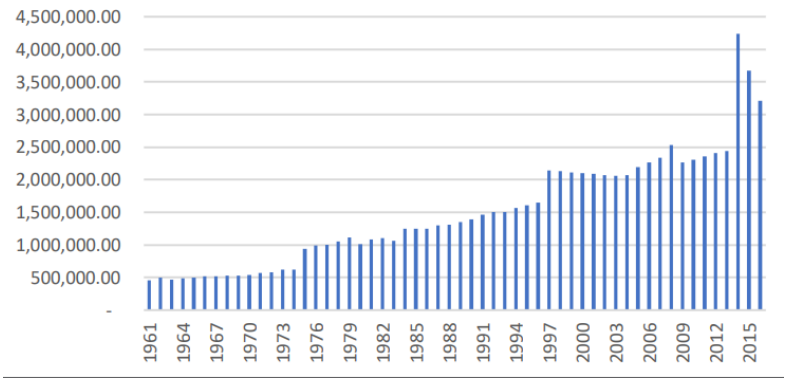
Crop	Production (Mt/y)	Crop	Production (Mt/y)
Yam	7,2	Sugarcane	1,9
Cassava	5	Plantain	1,8
Palm oil	2,1	Maize	1
Rice	2,1	Cashew nuts	688
Cocoa	1,9	Natural rubber	461
Banana	397	Cotton	316

Cassava

Main cassava production zones are the high rainfall forest areas of Center, the South and West- Central of the country, with the Sud- Comoe the most important. The sector represents employment to approximately 425.000 FTE jobs[58], most of which are in small scale retail, agriculture and artisanal production of cassava products. Until recently, cassava has been the food of the poor just to be eaten during famine times but today the cassava sector in Cote D' Ivoire is one of the priority export sectors by the National Export Strategy, on the basis of competitiveness criteria, export potential and socio-economic impact, mainly job creation for women and youth. The cassava sector shows a strong representation of women in all process steps, including in decision making positions. As in other more traditional oriented crops, children also help out in the production.

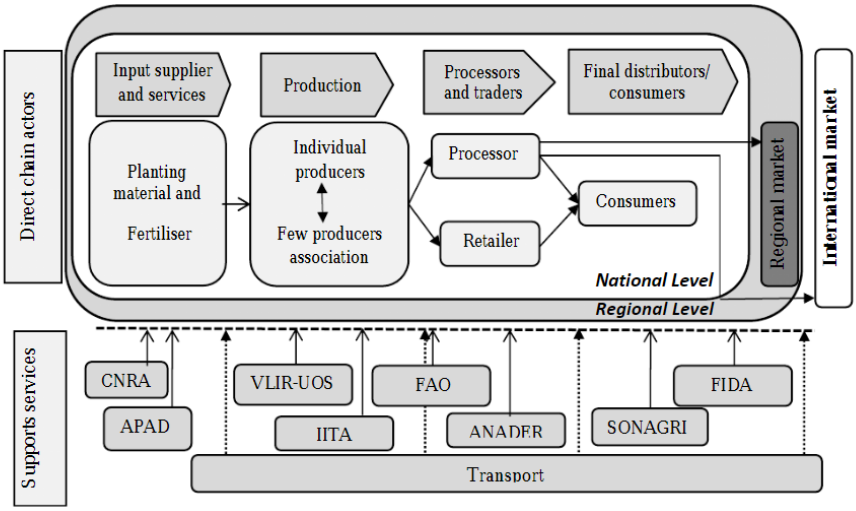
[55] *https://www.trade.gov/country-commercial-guides/cote-divoire-agricultural-sector*
[56] *https://www.ifad.org/en/web/operations/w/country/c%C3%B4te-d-ivoire*
[57] *FAO, Cote D' Ivoire production in 2018, available at: https://www.fao.org/faostat/en/#data/QC/*
[58] *https://www.rvo.nl/sites/default/files/2021/06/Study-of-the-biomass-potential-in-Cote-dIvoire.pdf*

Figure 14: Cassava production in Cote D' Ivoire[59]



Most of cassava producers are members of farmers organizations, with access to fertilizers and other agricultural inputs, although low fertilizer use remains common. Processors are a key part of the value chain, producing diversified cassava outputs. Processing centers, where peeling and other processing takes place can be divided into: family or neighborhood processing centers, associations or cooperative processing centers and mechanized processing centers. Cassava marketing and trading takes place at the local, national, and regional markets, with most of the traders being women.

Figure 15: Cassava value chain map in Cote D' Ivoire[60]



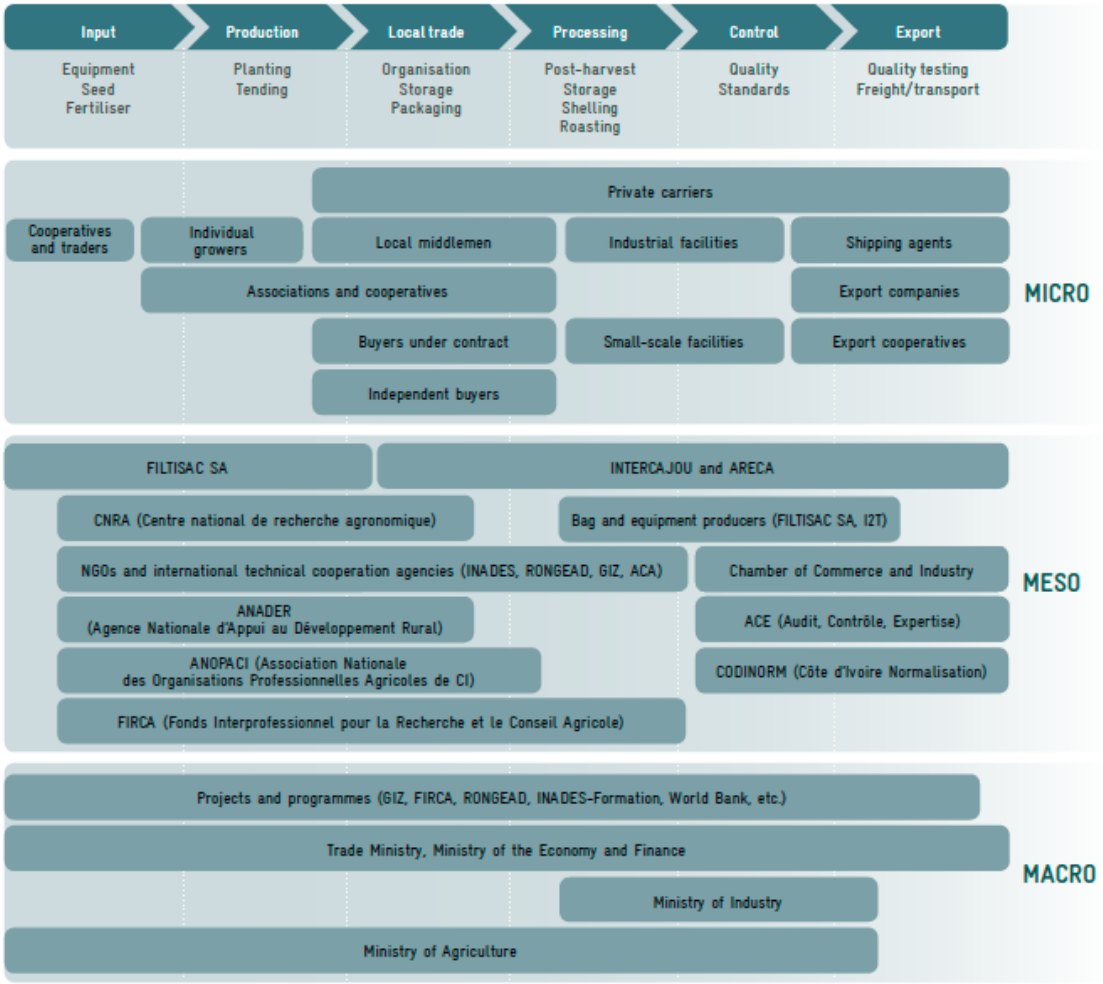
Cashew nuts

The country is one of the world's leading producers and exporters of raw cashew nuts. Cashew production takes place throughout a large part of the country and is most prominent in the regions of Béré, Gbeke and Hambol. The sector consists of farmers (330.000), mainly small-scale farmers, with women accounting only for 17% of all cashew farmers, being traditionally in charge of harvesting, transporting, sorting and drying the

[59] *https://cgspace.cgiar.org/bitstream/handle/10568/109172/U20RepAlamuReportNothomNodev-1.pdf?sequence=1&isAllowed=y*
[60] *Coulibaly et al., 2014 "Regional cassava value chains analysis in West Africa: Case study of Cote D' Ivoire", at https://www.researchgate.net/publication/269989401_REGIONAL_CASSAVA_VALUE_CHAINS_ANALYSIS_IN_WEST_AFRICA_CASE_STUDY_OF_COTE-D'IVOIRE*

fruit, rather that growing plantations. Yields are very low, with insufficient access to agricultural commodities such as insecticides and pesticides. Most farmers sell their products to local traders, intermediaries who either sell to independent buyers or big trading and export companies.

Figure 16: The actors of the cashew value chain in Cote D' Ivoire[61]



Rice

Rice in Cote d'Ivoire is mainly produced by smallholder farmers, for subsistence purposes. Smallholders often face low rice productivity, mainly as a result of a limited access to financing, quality seeds, adequate equipment and mechanization, together with poor post-harvest handling. Rainfed rice accounts for 95% of the area planted and 80% of total production. There are about 2 million producers organized in four informal cooperative groups[62]. In 2015, approximately 2.100 rice processing factories were operating in the country.

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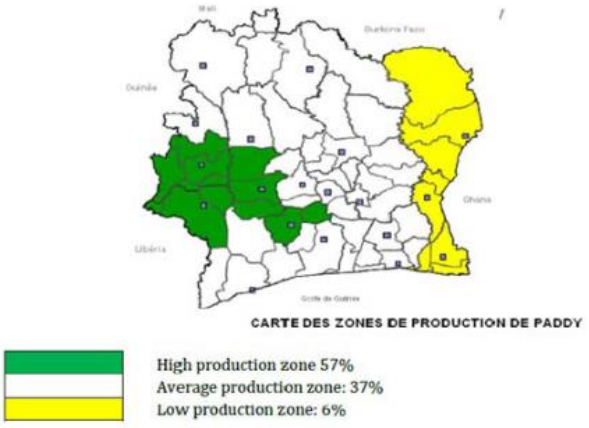
[61] *African Cashew Initiative (2010), "Analysis of the Cashew Sector Value Chain in Cote D' Ivoire", available at http://www.africancashewinitiative.org/files/files/downloads/aci_cote_d_ivoire_gb_150.pdf*

[62] *https://www.researchgate.net/publication/318312232_Feasibility_Study_of_Iron_Fortification_of_Rice_in_Sub-_Saharan_Africa#pfc*

Figure 17: Rice production zones in Cote D' Ivoire[63]



Rubber

Rubber is a traditional export crop for Cote D' Ivoire, with the country being the largest rubber producer in Africa and the fourth in the world. The plantations are mainly village based (89% of total surface area, 65% of national production), employing around 17.000 farmers. This crop, practiced in the northern part of the country, has faced significant difficulties since the outbreak of the political crisis in September 2002 but now is rapidly growing, reaching a production of 955.571 tn in 2020, noting an increase of 23% compared to 2019. 4 companies manufacture a range of rubber products. Constraints of the sector include high cost of machinery, lack of access to finance and shortages of skilled labor.

b) Livestock sector

Livestock rearing plays a key role in the economics of Cote D' Ivoire as meat consumption, particularly chicken meat, is increasing fast. Before the 2002-2005 crisis, the livestock and fisheries sector contributed approximately 2.9% to agricultural GDP and 1% to national GDP[64]. Despite the challenges described above, the sector has made and is still making a lot of progress towards self-sufficiency in a highly protected market space. In 2002, the following livestock populations have been recorded by FAO:

[63] *African Cashew Initiative (2010), "Analysis of the Cashew Sector Value Chain in Cote D' Ivoire", available at http://www.africancashewinitiative.org/files/files/downloads/aci_cote_d_ivoire_gb_150.pdf*

[64] *https://www.rvo.nl/sites/default/files/2019/11/Onderzoek%20pluimveesector%20Ivoorkust.pdf*

Figure 18: Livestock populations in Core D' Ivoire[65]

Species	Year			
	1980	1990	2000	2002
Cattle	666	1,108	1,409	1,341
Sheep and goats	1,920	2,022	2,585	2,713
Pigs	315	360	336	350
Poultry	17,000	24,120	29,400	32,625
Total LUs	758	1,069	1,324	1,338

Poultry plays an important social and cultural role in Cote D' Ivoire and constitutes an important part of subsistence farming, as, while it is not a generally primary economic activity, household sale of poultry generates revenue to cover other family needs (i.e. medical care, schooling, repay debts etc.). Family production in both urban and rural areas accounts for the majority (over 70%) of Côte d'Ivoire's poultry. They generally do not use feed, veterinary, or sanitary inputs. Under semi-intensive production (between 100-500 animals), feed contains a variety of products including grains, animal offal, and food scraps and is generally mixed by the producer. From 2010-2020, there has been a rise in large vertical integrations in the poultry value chain from farming to retail, whereas various middle-level value chain actors, such as smaller feed suppliers have grown. The production costs remain high and there is lack of well-trained and educated workers for the sector.

Cattle play an important social role and are often slaughtered for traditional, religious or family feasts. They are also a form of saving and commercial offtake is low. The commonest cattle production system is a sedentary one, with humpless cattle owned by farmers. Some transhumance or semi-transhumance is practiced by Peulh with Zebu herds.[66]

c) Construction sector

As of 2019, the construction sector in Côte d'Ivoire accounts for 10% of the workforce, making it the third-largest source of employment. The country's new National Development Plan 2021-2025 intends to strengthen infrastructure development, which will help the construction sector's growth. This agenda will also help increase exports and public investment. The housing need in Côte d'Ivoire is estimated at 400, 000 to 600, 000 units, with a yearly increase of 50, 000. Leading subsectors are the housing market, road construction and other large-scale infrastructure development. In addition to the abovementioned, the home remodelling market such as equipment, furniture and housewares retail, offers significant opportunities for economic development.[67]

[65] https://www.fao.org/ag/againfo/resources/en/publications/sector_briefs/lsb_civ.pdf
[66] *https://www.humanitarianlibrary.org/sites/default/files/2013/07/CotedIvoire-English.pdf*
[67] *https://www.privacyshield.gov/article?id=Cote-d-Ivoire-Building-and-Construction-Equipment-and-Materials*

d) Water filtration sector

35% of the rural population in Cote D' Ivoire struggles to access clean water and only 16 million people had access to basic drinking water in 2016.[68]The sewage and water sanitation systems are outdated and neglected. Around 41% of households in the study appeared to have E.coli present in the water they used for infants' formula, increasing the infant mortality rate. Women and girls are typically responsible for bringing clean water to their homes. Because they must walk long distances alone to fetch water, they face an increased risk of others abducting or harassing them along their route. Girls also forfeit attending school because of this responsibility.

Value chains SWOT analysis

Strengths	Weaknesses
All outputs Small- scale and fit to the local context technologies of low capital and operating costs Low complexity technologies, not requiring high level of knowledge and skills (pyrolysis, briquetting, bio-composites) Valorization of agricultural waste streams Innovative, environmentally friendly outputs **Biochar as soil amendment** Improved water use efficiency Improved soil fertility, especially for sandy soils Increased crop yield Reduced nutrient loss Low-cost soil amendment, suitable for smallholder farmers of low income Availability throughout the whole year Indirect reduction of other greenhouse gases through soil emissions **Biomass pellets as animal feed** Improved feed preservation Improved feed digestibility	**All outputs** Lack of relevant legislation and standards Limited access to information, communication and learning mechanisms Training of farmers on the technologies is required **Biochar as soil amendment** Effectiveness of biochar use as soil amendment is highly dependent on biochar synthesis, soil and crop types and quantities applied.

[68] *https://borgenproject.org/sanitation-in-cote-divoire/*

Strengths	Weaknesses
Less waste during production **<u>Biochar as additive in water filtration systems</u>** Answer to a very important need of local population (safe drinking water) Low cost, easy to use water filtration media	
Opportunities	**Threats**
Substitution of soya meal as animal feed Income diversification for farmers Knowledge exchange through collaboration with research institutes Start-up incubators for biochar producing companies	Potential negative health impacts of handling biochar Lack of long-term policy framework for supporting new energy systems Competition between different uses of residues to be used as feedstocks (rice husk) Inadequate after sales service Limited access to spare parts in the local markets High transport costs **<u>Biochar as soil amendment</u>** Resistance in adoption as farmers engage in traditional agroecological practices for soil enhancement **<u>Bio-composites/ Bioplastics</u>** Low acceptability by the population

Customers, customer segments and their needs

- **Farmers and rural households:** Farmers and rural households in Cote D' Ivoire struggle with timely access to credit, cost of finance
- **Farmers based organizations and cooperatives:** Ivorian agricultural producers organize themselves into producers' groups and cooperatives to control and manage the production and marketing channels for agricultural products. The National Association of Agricultural Producer Organizations of Côte d'Ivoire (ANOPACI) was created in 1998 to serve as a platform for exchange among national producers' organizations and to represent Côte d'Ivoire farmers at regional and international for a. The following enterprise specific producers' organizations are members of ANOPACI: APACI (cashew nuts); APROCACI (coffee and cocoa); APPORCI (pig producers) ; APROCASUDE (sheep and goat); APROCANCI et OPCN (rubber) ; OCAB (pineapple, banana and mango) PROMEXA (non- traditional

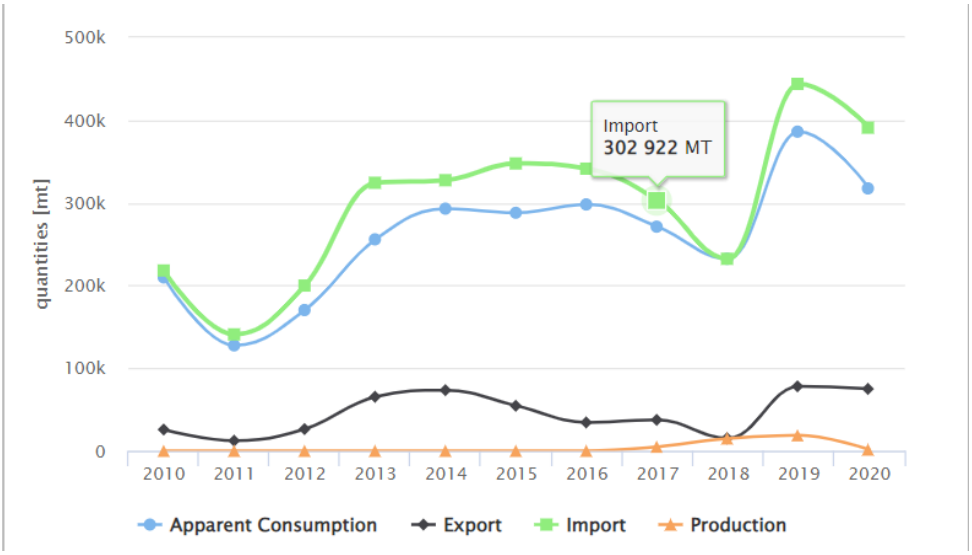
fruits) ; URECOS-CI-U-COOPAGCI (cotton) ; UACI (poultry) ; la PFACI (platform for women in agriculture in Côte d'Ivoire).[69]

- **NGOs:** NGOs in the agricultural sector are instrumental in providing advisory services to producers and farmers organizations, with their number continuing to grow, as a result of the political turbulence of the last years. The most important NGOs active in Cote D' Ivoire are: Organisation Conventionnelle des Actions Agricoles de l'Ouest de la Côte d'Ivoire (COCAOCI), Ferme et Agriculture (FERAGRO), Organisation des Volontaires pour le Développement Local (OVDL), Femmes Action pour le Progress, Femmes Actives de Côte d'Ivoire, Institut Africain pour le Développement Economique et Social (INADES), Convention de la Société Civile Ivoirienne (CSCI), Center for Research and Action for Peace (CERAP)
- **Commercial agricultural operators/ fertilizer distributors and sellers**
- **Water sanitation agencies (national or community level), organizations working on sanitation**
- **Construction companies and other professionals in the construction industry**

Level of competitiveness

- **Fertilizer producers:** Composts and organic fertilizers are the direct competitive products of biochar to be used as soil amendment. In national market, similar products of national multi-nationals (Yara, Callivoire), products of large national companies; and products of SMEs exist. Multinationals cover the major market share. The respective industry is growing at a slow pace, which is not expected to change after the introduction of biochar as soil amendment, as studied in BIO4AFRICA novel biochar value chain development.

Figure 19: Fertilizer trends in products[70]



[69] *https://www.g-fras.org/en/world-wide-extension-study/africa/western-africa/ivory-coast.html#extension-providers*

[70] *https://africafertilizer.org/cote-divoire/#tab-id-2*

- **Animal feed producers:** The Ivorian animal feed sector is divided in the formal and informal sector: the formal sector comprises of multinational, large national companies and small-scale feed mills exist. The poultry industry (broiler and layer) is currently the largest animal feed industry in the country and accounts more than 90% of the feed production[71]. Major players in poultry feed in the country are SIPRA, Foani, FASI, Provato and Koudijs). Main competitive products to BIO4AFRICA output could be corn bran, cotton cake and industrial animal feed, products of multinationals (CIPRA, IVOGRAIN), products of large national companies (FOANI); and SME products. Relatively few raw materials are available to the feed manufacturing industry, including cereals, maize, cotton seed cake. Premixes and concentrates are imported. Distributors of premixes and concentrates include Koudijs, Maridav, Proveto, Mailvage and Sifaal[72]
- **Water filtration systems:** Existing competitive products for water filtration systems: carbon filters. Products of Multinationals (Chinese Water Filter, China Fair, Market Day, Abidjan Mall), products of large national companies (Peryssac, ORCA, Chic Shop);; and products of SMEs
- **Packaging materials:** Plastic packaging produced by multi-nationals, large national companies (OK-Plast, COTI-Plast etc.); and SME products.

Potential collaborators

Based on Task 1.2 of BIO4AFRICA, value-added commercial opportunities on the targeted agricultural waste of BIO4AFRICA Ivorian case include:

- Use of cassava leaves as cattle feed (e.g., for poultry, goats, sheep).
- Use of cassava processing by-products (e.g., dry peels, tubers) as cattle feed (e.g., for pigs).
- Export of cassava starch in the paper industry as a binding agent in pulp production to create higher-value paper.
- Export of cassava starch as an agent in the textile industry for producing better quality and resistant printed fabric.
- Export of cassava starch for food industry applications, e.g., thickener, binder, expanding agent, stabilizer, carrier of sweetener and condiment.
- Export of cassava starch for application sin the beverages industry, e.g., sweetener.
- Export of cassava starch for candy production purposes, e.g., gelatinize, thickening, enhance foam, control crystallization, and enhance candy gloss.
- Collect and export mechanised processing by-products of cashew nuts (e.g., split, broken cashew kernels) that are used to the confectionary industry, particularly in the U.S. and Europe.
- Process cashew nuts processing by-products (e.g., shells) for the production of cashew nutshell liquid oil, energy or charcoal and organic fertilisers.

[71] *https://www.fao.org/fishery/docs/CDrom/aquaculture/a0844t/docrep/008/a0042e/a0042e06.htm*
[72] *https://www.rvo.nl/sites/default/files/2019/11/Onderzoek%20pluimveesector%20Ivoorkust.pdf*

Additionally, the following actors have been identified as potential collaborators for BIO4AFRICA outputs rollout in Cote D' Ivoire:

- **Cashew nut processing companies**
- **Soil amendment producers and sales networks**
- **Waste collectors/ waste sorters**
- **SODECI** (public operator of drinking water)
- **ANADER** (Agence Nationale d'Appui au Développement Rural)

3.3.3 Market conduct analysis

Competitive rivalry within the market

Although the local scientific community has been interested in biochar, it is produced only in small quantities in an artisanal way on site and almost exclusively to be used for energy. For example, cocoa bean shells have been tested for this purpose to power grinding and pressing at cocoa processing facilities. Cocoa producer Barry Callebaut is producing biochar at several of their production sites. TNO has been also working on a cocoa bean shell biochar pilot with Olam

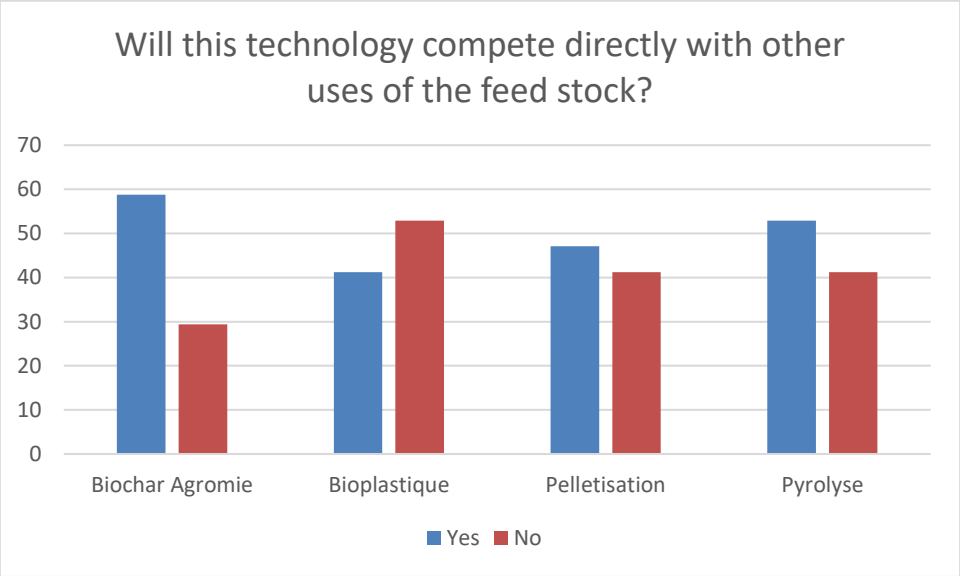
The soil amendment market is not well developed in Cote d'Ivoire. Efforts need to be made to raise farmers' awareness of the importance of organic amendments for the productivity of their soils. Existing agri-based industries offer diversified products in their portfolio for soil amendment and fertilizing purposes. There are different players of very different sizes. We can distinguish two groups: i) large-scale industrial producers of mineral fertilisers who also produce calcium-based soil amendments (lime), which production is not very large because very few players use it. ii) producers of organic fertilisers who are starting to develop but still on a small scale. Biochar as soil amendment could be added in the product portfolio of existing market players in the fertilizer/ soil amendment market.

Regarding animal feed pellets, it should be noted that in Côte d'Ivoire, there is already a large network of industrial production and distribution of pelleted feed for various types of livestock. Prices are relative and depend on the company. Granulated feeds are more expensive. In terms of industrial animal feed, the main players are IVOGRAIN, FACI and FOANI, Ivorian companies. In addition, we have many companies that market imported concentrated or complete feeds.

Regarding water filtration and sanitation, there is SODECI, the state enterprise responsible for drinking water distribution and community level enterprises. These are industrial water treatment systems. There are also several types of small and cheaper filters manufactured in China or other countries for household use. The drinking water deficit amounts to 160,000 m3/day in the capital Abidjan, i.e. a ratio of 32 liters per inhabitant per day. The use of water from wells, rivers and backwaters is the alternative that poor households have in order to access drinking water.

As resulting from Task 1.4 of BIO4AFRICA, in Cote D' Ivoire, 28% noted that there is no competition on uses of the feedstocks for biochar production, 55% for bioplastics, 40 % for pelletization and 42% for pyrolysis.

Figure 20: Competition with other uses of feedstock in Cote D' Ivoire[73]



The threat of new market entrants

The potential of new cooperative consortia with interested investment parties could be of the utmost importance for the new market entrants. By the entry of biochar as soil amendment in the market, existing established agro-based industries are expected to strengthen competition by improving the performance of existing soil amendment/ fertilizers, align of existing products to match the environmental benefits of biochar and partner with other market players in order to avoid competition. The successful introduction of biochar as soil amendment presupposes awareness raising activities, on farm training and after sales support and guidance to ensure crop yield increase. Another important parameter to be taken under consideration is the quality of the product, that must cover the majority of farmers' needs in terms of crop yield and quality amelioration. BIO4AFRICA entails several research and adaptation, piloting, validation and business activities on the production and use of biochar as soil amendment in the target countries, with the aim to reveal how feedstock properties and operating conditions affect the quality of soil amendment produced and how the economics are determined. This should be considered as a major unique selling point of our solutions compared to possible new entrants. Raising awareness and accelerator activities that are planned under BIO4AFRICA offer a major advantage compared to possible new entrants.

The use of biochar in water filtration systems requires specific training and after sales service to customers in order to make a successful market entry.

Economic relationships within markets

Cashew, cotton and rubber constitute priority sectors for diversification and domestic value addition. These products have significant potential to be the basis for diversification into associated derivative products.

[73] *Sedi, M., Kyalo, W. D., & Marechera, G. (2021). Diversifying revenue in rural Africa through circular, sustainable and replicable biobased solutions and business models - D1.4: Co-definition of technologies to be transferred with local farmers and communities.*

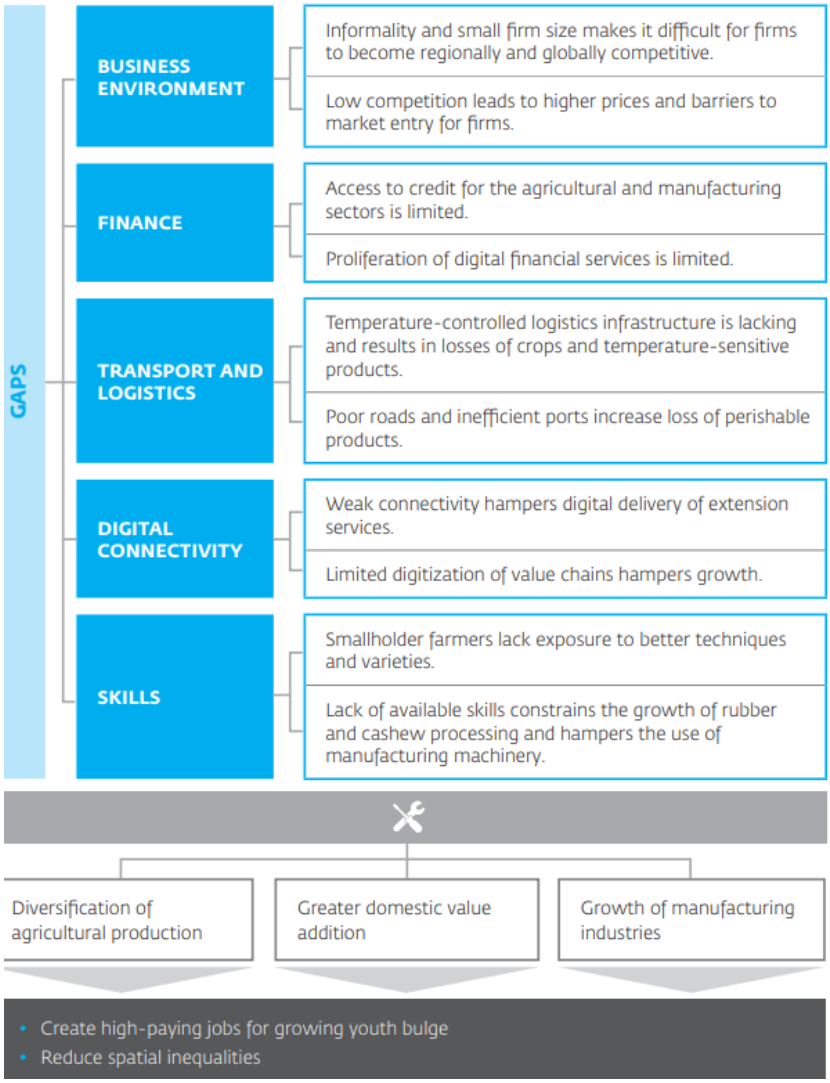
Growing and processing cashew and rubber are employment-intensive – including for women active in the transformation of cashew nuts and cotton – and would contribute to reducing spatial inequality between the North and the South, as well as gender imbalances.

Growth opportunities also exist for the rubber and plastics manufacturing industry, with the reduction of tariff and non-tariff barriers existing previously.

Yet, there are sectors cross-cutting constraints that characterize the business environment of Cote D' Ivoire, as can be seen in the

Figure 21 below:

Figure 21 : Cross- cutting constraints in the business environment of Cote D' Ivoire [74]



[74] *https://www.ifc.org/wps/wcm/connect/c3d1ae63-80d1-44a7-8b5f-959e38b4fd09/CPSD-Cote-d-Ivoire.pdf?MOD=AJPERES&CVID=nk4XA5J*

Patterns of commercial behaviour

In Côte d'Ivoire, feed costs currently represent 65 to 70% of animal production costs. The high cost of feeds is due to imports of certain raw materials or feeds used for feed formulation such as soya or concentrates. However, some raw materials such as maize, produced locally, are subject to price increases of between 100% and 150% in periods of shortage, while the market prices of animals have remained at the same level for several years.

It should be noted that in Côte d'Ivoire, there is already a large network of industrial production and distribution of pelleted feed for various types of livestock. Prices are relative and depend on the company. Granulated feeds are more expensive.

Many formulations known as biofertilizers are sold at prices ranging from 15 to 41 euros per bottle and are used in the country as fertilizers or as plant vigor enhancers in agricultural soils.

Regarding the women role on the daily operative of business activities, it has been concluded by BIO4AFRICA Task 1.1 surveys[75] that males are in the predominant role of leading both work and household decisions. A possible explanation is on the basis that culturally, women are not associated to decision making in community ecosystems. On this regard, women role in farming activities is more linked to manure than agricultural raising and harvesting. Using animal waste as compost for the fields can also be considered a usual practice among daily women operative. Collaborating and discussing male decisions based on the selection of fertilizers, setting prices, and adjusting budgets are common practices made at household level. Most female owning their land are linked to cooperative schemes and group insurance policies. Usually, a "women" chief is designated to speak to the rest of women cohabitants, especially regarding subsidies directed to women welfare and job opportunities.

3.3.4 Market performance analysis

Bargaining power of customers

Horizontal collaboration is a source of competitive advantage in agriculture and horizontal relationships in the value chains have great bargaining potential. At the country level, many farmers are not organized in cooperatives and are yet to professionalize. The case is somewhat different for cashew nut producers, who already operate in groups. These groups can collaborate to purchase improved machines of greater capacity and efficiency to benefit from the economies of scale, gain access to credit at lower rates etc.

For more information on collective entities of farmers, please check page 71 of the current report.

Farmers who can afford it use chemical fertilisers to boost their crops, but often the misuse of these chemicals leads to rapid soil degradation. Also, the increasingly high cost of these products excludes a large proportion of small-scale farmers in rural areas from using fertilisers. Biochar, whose production from locally

[75] *Garcia, M., Sedi, M., & Willy, D. (2021). BIO4AFRICA - Diversifying revenue in rural Africa through circular, sustainable, and replicable biobased solutions and business models - D1.1: Contexts and needs of African rural communities.*

available biomass and cost are accessible to all these farmers, is an interesting alternative for the amendment and rehabilitation of poor or degraded soils.

Bargaining power of suppliers

The annual production of agricultural waste in Côte d'Ivoire is estimated at 17 million tons per year, hence the need to valorise them to give them an added value, to fight against deforestation on the one hand and on the other hand to contribute to reduce the intensive use of synthetic fertilizers. Côte d'Ivoire's intends to collect 860 to 1800 t/year of raw materials for biochar production to have 230 to 500 t/year in cruise production of the company. The chosen feedstocks (cassava peelings, rice husk) are less expensive, abundant all year round and easy to obtain in the country.

60% of cassava peels are used in raw or dried form in animal feed Hevea seeds are hardly used for nurseries (less than 10%). The remaining seeds germinate in the field and require the use of herbicide to be removed. Cassava peelings are collected in the cities or villages from cassava processors. The quantities available are sufficient but disparate across the country.

Soybean meal is imported and used in animal feed. However, its cost is high, and its substitution is increasingly being considered.

Corn stalks are also used for biochar production.It is estimated that cassava peelings amount to a total of 588.000 tn in 2019[76], representing 5-15% of the total weight of the cassava root. They are mainly used in livestock feed applications.

The cashew processing industry is still in its infancy, with a limited number of processing units which started operations in the last decade. Cashew processing is carried out by three types of facilities: large industrial of over 1000 t/year capacity, semi-industrial facilities with an average capacity between 500-1000 t/year and small facilities of artisanal character with less than 500t/year capacity. A list of the most important cashew nut processors in the country is presented in the Table 21 below:

Table 21: Overview of cashew processing units in Cote D' Ivoire[77]

Name	Installed capacity (t/y)	Name	Installed capacity (t/y)
Afrique Agri Industries	70.000	Foods CO S.A.	6.000
OLAM 1	30.000	CITA	6.000
Cilagri Cajou	30.000	Côte d'Ivoire Cajou	6.000
GIE/GEPPA	30.000	Cajou des Savanes	5.000
OLAM 3	15.000	SOBERY	5.000

[76] *https://www.rvo.nl/sites/default/files/2021/06/Study-of-the-biomass-potential-in-Cote-dIvoire.pdf*
[77] *https://www.rvo.nl/sites/default/files/2021/06/Study-of-the-biomass-potential-in-Cote-dIvoire.pdf*

Name	Installed capacity (t/y)	Name	Installed capacity (t/y)
NOVAREA	15.000	Africa Negoce	5.000
Ivory Cashew Nut (ICN)	15.000	Agriculture Ivoirienne AISA	5.000
Huxley Global	15.000	Global Cashew	3.500
Dorado Ivory	15.000	KIYO	3.000
OLAM 2	12.000	AGRO FRONAN	3.000
Ivoirienne de Noix de Cajou	12.000	CAJU INDUSTRIE	3.000
FMA Industry	10.000	BOHAIMAN Group	3.000
Société Ivoirienne de Traitement de l'Anacarde (SITA)	10.000	Transua Cajou	2.500
Quan Thien Imex	10.000	AFRICAJOU	2.000
Denia Ivoire SA	10.000	Cajou de Fassou	1300
Nord Cajou	6.000	COOPABO	1000
Société de Treansformation de Noix de Cajou (STNC)	6.000	Benie Cajou Ivoire	1000
SCOOPCA COPRODIGO	360		

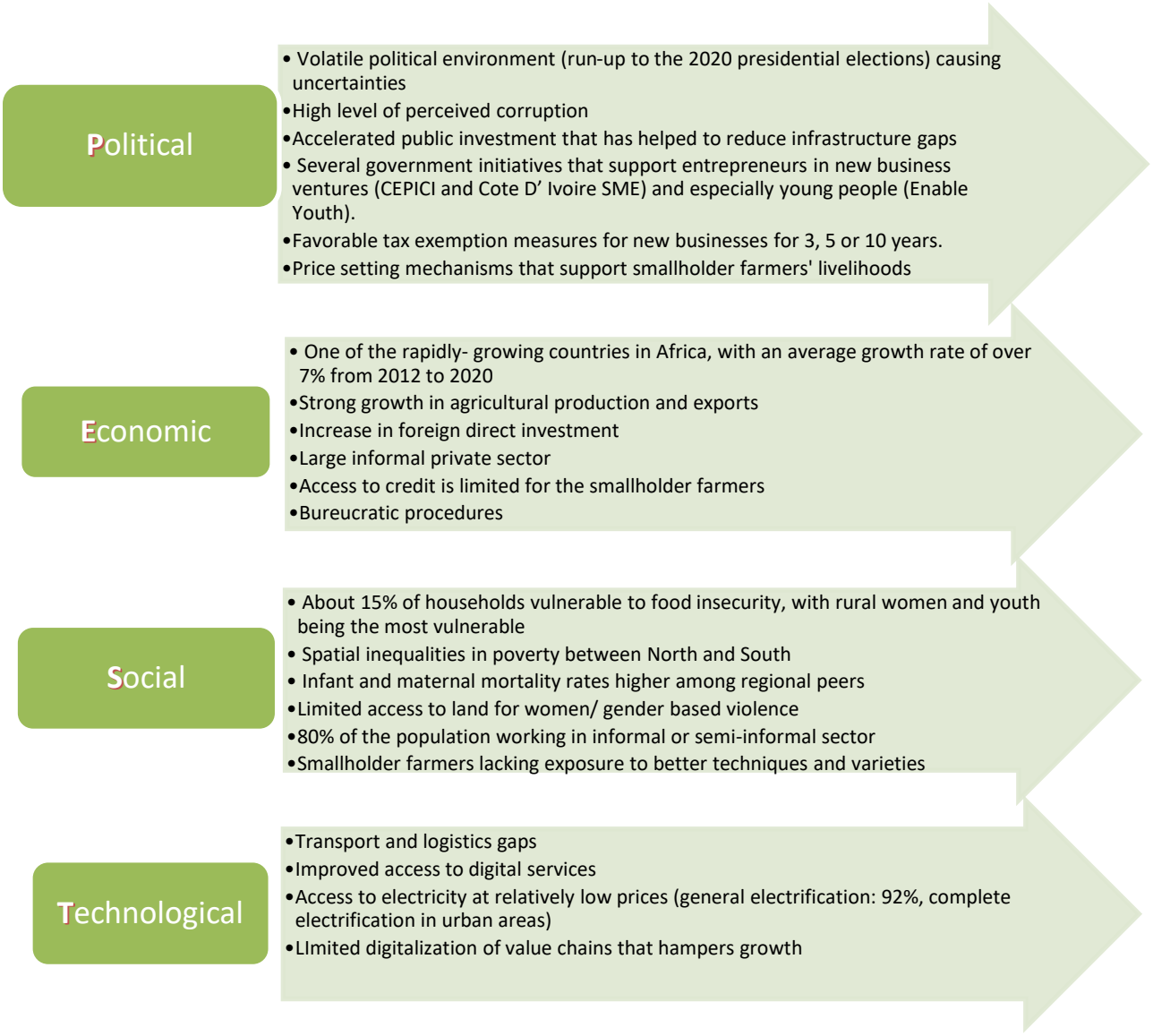
. Cashew nut husks are collected from processing plants in the north and centre of the country. Cashew kernel waste (broken kernels) used to be used for animal feed. However, today these by-products have become rare. Other cashew by-products such as cashew husks are increasingly being studied. The cashew nut shells, once broken, release cashew nutshell liquid (CNSL). In some cases, cashew nuts are combusted directly as an energy source. CNSL, which is globally traded, can be used for a variety of products, such as surface coatings, paints and varnishes, as well as in the production of polymers. When incinerated, creates toxic fumes, leading to air pollution and health issues. The upgrade of raw cashew shells by pyrolysis to produce biochar is the preferable application from an environmental and economic perspectives. The production of CNSL has previously been conducted by two of the larger cashew processors in CDI, OLAM and Sita, but has ceased due to the low CNSL price[78].

[78] *https://www.rvo.nl/sites/default/files/2021/06/Study-of-the-biomass-potential-in-Cote-dIvoire.pdf*

Cashew apples can be used for the production of alcohol and channeled to various industries such as the alcoholic drink industry and pharmacy suppliers or used to produce ethanol fuel. For the time being, cashew apples produced in large quantities (around 10 million tonnes) are not valued and are left to rot in the fields.

Côte d'Ivoire produces more than 10 million tons of empty pods per year and about 50,000 tons of coir fiber. Côte d'Ivoire expects to collect 2,000 to 3,000 t/year of roast tree fiber and empty cocoa pods and produce about 15,000 to 20,000 t/year of bio composites.

PEST analysis



Trends, growth prospects & potential socio-economic impact.

Prior to the shock triggered by the pandemic, Cote D' Ivoire had one of the most robust economies in Africa. The COVID-19 crisis severely affected Ivorian households and businesses, slowing down the growth rate to 1,8% in 2020. Domestic demand and stable exports are expected to drive the economic turnaround in 2022, bringing strong growth in 2022 and 2023 with manufacturing, services and exports being the most supportive

sectors. Despite economic growth though, the country has a very low Human Development Index (ranked 162 of 189 in 2019).

A reform agenda that fosters is needed that allow sustainable economic recovery and more inclusive growth. These could be done by promoting the private sector in order to create better jobs, provide access to financing for SMEs, build capacity in the agricultural sector, and develop human capital, among other things

3.4 Senegal

3.4.1 Value chains definition

In Senegal, BIO4AFRICA aims to test technologies for processing various types of local agri-food and forest waste streams to biochar, raw biomass briquettes and bio-composites. In the following Table 22, the identified value chain/ product- market combinations of BIO4AFRICA in Senegal are being summarized, along with the corresponding feedstocks and technologies.

Table 22: BIO4AFRICA product- market combinations in Senegal

Product	Feedstocks	Technology
Biochar powder for additive in biogas production systems	Peanut shells, cashew nut shells, millet stalks, rice husk	Pyrolysis
Biochar powder for soil amendment		Pyrolysis
Biochar briquettes and powder for solid fuel		Pyrolysis, briquetting
Biochar briquettes and powder for solid fuel and soil amendment	Typha, mahogany fruits	HTC, briquetting
Raw biomass briquettes for solid fuel	Peanut shells, cashew shells, millet stems	Densification
Bio-composites for composite panels	Lignocelullosic fibres coming from agrifood and forest waste streams	Bio-composites production process

BIO4AFRICA technologies and technology combinations in Senegal

In Senegal, a **community level pyrolysis system** will be adapted and tested in order to produce biochar powder from major dry and wet local agricultural by-products (peanut shells, cashew shells, millet and corn stalks, rice husk etc.). Various feedstock blends and pyrolysis operating parameters will be defined and tested, depending on the availability of feedstocks and intended final use of biochar to be produced (soil amendment, additive in biogas production systems, solid fuel). Any necessary pretreatment steps required (i.e. torrefaction, pressing) for crop residues to be used as feedstocks will be assessed and optimized during the pilot phase implementation. The pyrolysis technology will be complemented with a **briquetting line**, adapted to the local needs, to deliver biochar briquettes to be used as solid fuel. For biochar production to be used as cooking fuel and soil amendment, an **HTC batch operation** pilot scale unit will also be developed using local, wet feedstocks such as Typha and mahogany fruits. Additionally, a **densification process** will be employed to produce briquettes from raw local biomass waste streams (peanut shells, cashew shells, millet

stems), that will be used as cooking fuel. Finally, a simple, low-cost production process of **bio-composites** from local fibrous vegetable waste and forest waste streams.

Biochar as a soil amendment

In Senegal, **biochar** will be used in millet, rice, sorghum, peanuts and cashew crops as **soil improving material** in closed-loop systems. Adding biochar to soil has been found to increase crop yield, to increase water retention and to increase soil stability, affecting the retention and mobilization of existing nutrients for plant uptake. Moreover, it releases carbon much more slowly than biomass left on field and thus contributes to carbon sequestration. The potential agronomic benefits reported by biochar practitioners are not only greater yields, but also better predictability in yields, reduced germination time, extension of the cropping season, and improved resilience to drought[79]. The link between feedstock used, pyrolysis process conditions, crops that the biochar will be applied and quantities per soil volume will be studied under BIO4AFRICA pilot and validation activities, to optimize biochar performance. Feedstocks used to produce biochar in *all pilot countries* will be characterized by geographical locality, through a closed-loop approach, so as not to disrupt the nutrients cycle.

Biochar and raw biomass briquettes as solid fuel

Biomass and biochar briquettes will be produced in BIO4AFRICA pilot case in Senegal to be used as solid fuel. The compaction of biomass through briquetting improves its combustion properties and makes transport, distribution and storage easier and more cost-effective. The briquettes produced can be used as a substitute of coal, charcoal and firewood for domestic cooking or for industrial uses (fuel in electric power generation, fuel for heat and steam production in industrial boilers).

Biochar for additive in biogas production systems

Biochar powder will be used as an additive in biogas production systems to act as a catalyst for anaerobic digestion and as a filter for biogas pollutants (namely H_2S) in biogas digesters. Parameters to be assessed include reduction of waste gas in biogas, microbial diversity evolution, reactor alkalinity, pH, Volatile Fatty Acid concentration etc. More precisely, biochar could increase the kinetics of biogas production, and also its yield, as shown in relevant literature[80]. The benefits of the bio digester are multiple, including provision of gas for cooking and lighting and compost for soil amendment. However, this application is still at an early stage of development, and the definition of specifications on biochar properties seems crucial, because mechanisms involving biochar in anaerobic digestion are poorly understood. In the project, screening tests will evaluate, at laboratory scale, the performance of biochar with much differentiated properties.

Bio-composites for construction materials

With a view to taking a step further towards re-using and transforming agricultural waste in value-added products, appropriate processes will be researched and developed to produce bio-composites. Local fibrous and dry agricultural waste such as primary wooden biomass (small branches, thinning woods, and/or residues of wood processing) and secondary biomass (fibre crop residues like straw, rice, palms etc.) as well as Typha will be mixed with resin/binding agents and hot-pressed at a small-scale prototype that will be developed for

[79] *Scholz, S. M et al. (2014) "Biochar Systems for Smallholders in Developing Countries: Leveraging Current Knowledge and Exploring Future Potential for Climate-Smart Agriculture". World Bank Studies. Washington, DC: World Bank. doi:10.1596/978-0-8213-9525-7.*
[80] *Scarlat and Kougias (2018). "Water- Energy- Food- Ecosystem Nexus in Western Africa: Small-scale sustainable solutions and energy from agricultural organic waste", Ispra, European Commission, 2018, JRC111857.*

BIO4AFRICA, in order to produce bio-composites in the form of panels. These fibrous panels will be lightweight with several potential non-structural load bearing indoor applications (false ceiling, furniture, interior walls, insulation etc.).

3.4.2 Market structure analysis

Target markets and size

The following markets/ sectors and market segments have been identified as targets for the exploitation of outputs that will emerge from the technology solutions to be tested in the BIO4AFRICA Senegal case:

Table 23: Target markets and market segments in BIO4AFRICA Senegal case

Output	Main market	Market segments
Additive in biogas production systems (biochar)	Energy sector	Domestic or industrial biogas production sector
Soil amendment (biochar)	Agricultural sector	Peanuts sector Cashew nuts sector Millet sector Rice sector Sorghum sector
Solid fuel (biochar briquettes, biomass briquettes)	Energy sector	Domestic energy sector
Bio-composites	Construction sector	Local eco-materials sector

e) Agricultural sector in Senegal

The largest part of Senegal lies within Sahel region or warm arid and semi- arid tropics with generally poor soils. Agriculture is central to the economy of the country. In 2016, agriculture represented 18% of Gross Domestic Product (GPD), employing 52% of the total labor force, with 80% of population in rural areas working under this sector[81]. 95% of the country's agricultural land is worked by very small-scale family-based farms engaged in subsistence agriculture. Farming systems are mostly rain- fed. Arable land is around 3.200.000 ha with only 63.000 of them irrigated[82]. Ground nuts, millet, rice, corn and sorghum are the primary food crops grown in Senegal. Despite agriculture's importance in national economy, the sector is negatively impacted by land access problems, irregular rainfalls, poor soils, deterioration of forests and water

[81] *https://www.syngentafoundation.org/agriservices/wherewework/senegal*
[82] *https://www.yieldgap.org/senegal*

resources (in quality and quantity). Senegal imports almost 70 per cent of its food and food insecurity remains a constant concern in the country. The production of major staple food crops covers barely 30% of consumption needs, with the remaining 70% being imported- mostly rice, wheat and maize. This dependence on global markets exposes households to price fluctuations and greater vulnerability. Women produce 80% of the country's food, thus empowering them is critical to the development of the sector.[83] The development of agriculture is at the heart of the Senegal Emergent Plan (PSE) through the program component of Recovery and Acceleration of the Agricultural Cadence in Senegal (PRACAS). This component stipulates rice self-sufficiency through irrigated and rainfed rice production, peanut production as part of a value chain approach and the development of market gardening and horticulture, a segment dedicated mainly to exports.[84]

Table 24: Agricultural production statistics in Senegal (year: 2016)[85]

Crop	Area harvested (ha)	Yield (t/ha)	Production (t)
Groundnuts, with shell	880.000	0.8	719.000
Millet	857.973	0.7	612.563
Rice, paddy	225.324	3.9	885.284
Maize	189.973	1.7	314.703
Sorghum	188.380	0.9	161.645

Rice

Rice is the most consumed cereal in Senegal and a critically important staple crop. Senegal is one of the largest consumers of rice in West- Africa, however, a considerable portion of rice comes from imports ($437M in 2020), making the country the 16th larger importer of rice in the world[86]. Rice farming systems in Senegal are highly variable depending on the region. Rice yields are largely challenged by infestation from weeds and birds and water scarcity. As more than 50% of rice is cultivated in irrigated conditions in northern Senegal and rice is grown in highly intensive systems there, rice yield at national level is higher than for other crops. However, rainfed lowland rice is also quite common in southern part of Senegal, where rice yield is generally low with low-input, rainfed systems. It accounts for 24% of total rice area, whereas rainfed upland rice accounts for 21%[87].In most regions, farming plot sizes are very small (<0.1 ha), with an average yield of 1-2t/ha and product destination are for consumption[88]. Regarding processing infrastructure, a significant

[83] *https://www.ifad.org/en/web/operations/w/country/senegal*
[84] *https://www.eurocham.sn/Agriculture+in+Senegal*
[85] *https://www.yieldgap.org/senegal*
[86] *https://oec.world/en/profile/bilateral-product/rice/reporter/sen*
[87] *https://www.yieldgap.org/senegal*
[88] *Gemill- Herren B. et al. (2019) "A holistic Lens on Rice Value Chain Pathways in Senegal: Application of "The economics of Ecosystems and Biodiversity for Agriculture and Food" Framework", TEEB AgriFood Initiative, available at http://teebweb.org/wp-content/uploads/2020/09/Senegal-Rice-LC.pdf*

number of small rice hulling facilities is operating in Senegal, which compete very well with large, inefficient, and costly rice mills owned by the state. Since the 1980s, the country has emphasized rice production through subsidies, extension, and infrastructure, but has failed to compete with imported rice. Addressing such challenges as cost of fertilizers, access to irrigation water, high processing and logistics costs, high energy prices, interruptions in the grid's energy supply can boost local production of rice.

Figure 22: Rice imports and production in Senegal (FAOSTAT)[89]

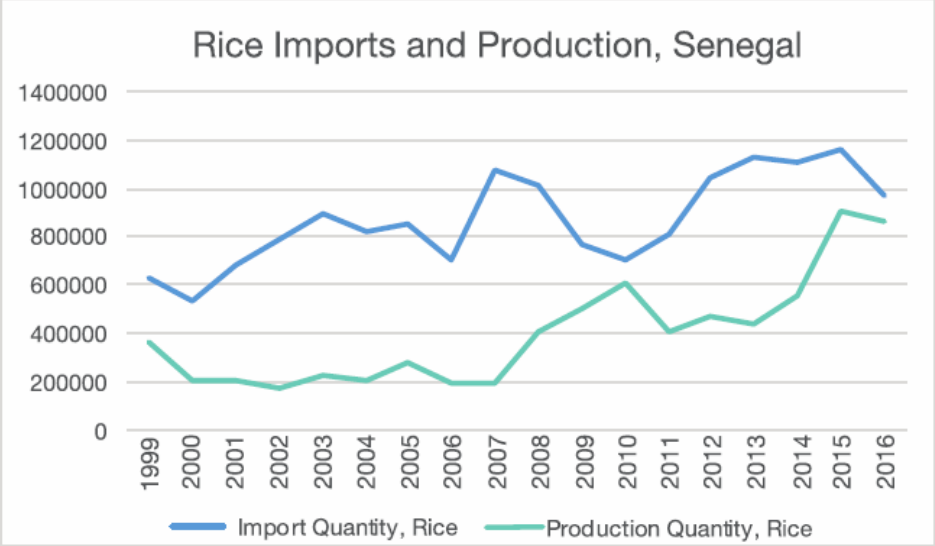


Table 25: Rice farming systems in Senegal according to region (adapted[90])

Characteristic	Saint-Louis	Matam	Fatick	Kolda	Ziguinchor
Rice as staple food	Primary	Primary	Secondary	Secondary	Primary
Farming environment/ varieties	Irrigated/high yielding	Irrigated/high yielding	Rainfed/ local partly improved	Rainfed/ local	Rainfed/ local
Plot size	Large (>1ha)	Medium (>0.25ha)	Small (<0.1ha)	Small (<0.1ha)	Small (<0.1ha)
Main cultivators	Men	Men & Women	Women	Women	Men & Women
Fertilizer usage	High	High	None to minimum	Low	None to minimum

[89] *https://www.yieldgap.org/senegal*

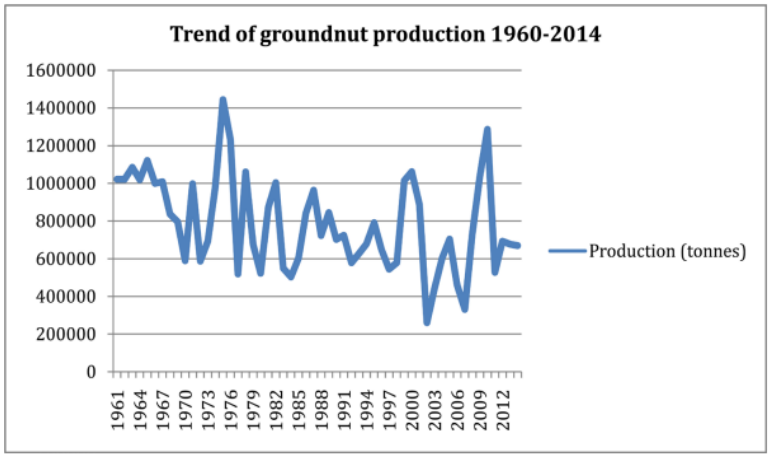
[90] *Gemill- Herren B. et al. (2019) "A holistic Lens on Rice Value Chain Pathways in Senegal: Application of "The economics of Ecosystems and Biodiversity for Agriculture and Food" Framework", TEEB AgriFood Initiative, available at http://teebweb.org/wp-content/uploads/2020/09/Senegal-Rice-LC.pdf*

Characteristic	Saint-Louis	Matam	Fatick	Kolda	Ziguinchor
Average yield	>5t/ha	>4t/ha	1-2t/ha	1-2t/ha	1-2t/ha
Destination	Consumption, sale	Consumption, sale	Consumption	Consumption	Consumption

Groundnuts

Groundnut production has historically played a central role in Senegalese rural economy. Groundnuts are grown by 27% of all households in Senegal, by 70% of the local population in the Groundnut basin covering a large swathe of central and western Senegal, and by 52% of households in extreme poverty, accounting for about half of the total cropped area in the country[91]. Senegal was once one of the most significant worldwide players in the ground nut industry, but years of adverse climatic events, soil degradation in combination to inefficient policies and poor agricultural management have eliminated production levels.

Figure 23: Groundnut production in Senegal between 1960-2014[92]



Groundnuts are basically found in four different product categories: groundnuts in shell, shelled groundnuts, ground-nut oil and groundnut cakes. There are three major categories of farms in Senegal's groundnut sector: a) standard smallholder groundnut producers, with below-average input use and yield, b) irrigated farms with very high levels of inputs and yields for sale in the off-season when groundnut prices are high, c) agricultural cooperatives with access to above-average levels of inputs and yield to sell groundnuts either for seed or for export. Transport and handling of groundnuts from the farm to end-users plays a crucial role in the value chain. Transporters were brought into government sponsored price negotiations to set farmgate prices and transporter payments at the beginning of each season. Transporters may also provide other

[91] *World Bank (2017) Senegal Groundnut Value Chain Competitiveness and Prospects for Development. World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/28399 License: CC BY 3.0 IGO*

[92] *Ndiaye, Georges et al., (2016) "Potentials of the Groundnut Sector towards achieving food security in Senegal", Open Access Library Journal, 2016, Vol. 3, e2991*

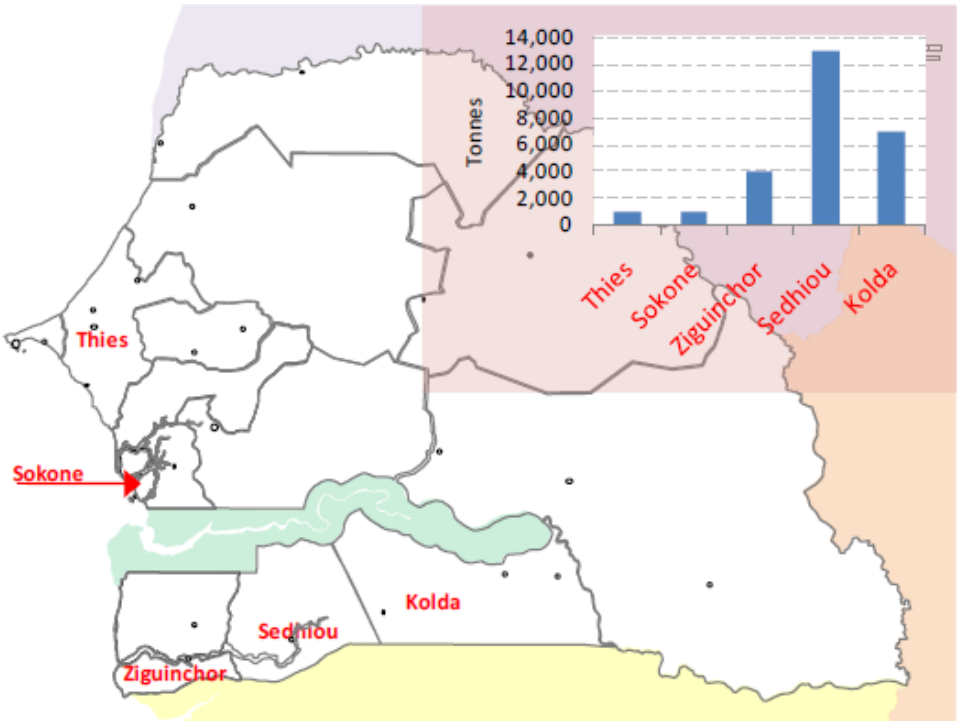
services related to groundnuts and other crops, including storage. Additionally, more diversified agrifood enterprises, known as operateur privé stockeur (OPS), are now transporting large quantities of groundnuts.

Industrial processing of groundnuts into oil has historically taken over half of the groundnut harvest, the vast majority of which is then exported in crude form. Industrial oil expressers such as SUNEOR/SONACOS move large quantities of groundnuts around the country to their centralized factories for processing and shipping. On the other end of the spectrum are dispersed artisanal oil processors who purchase from local markets and sell crude and refined oil for that same market. The global groundnut trade has gradually shifted from oil and meal to whole nuts, but Senegal, lagging behind global trends, has only recently liberalized exports of whole nuts.

Cashew nuts

Cashew nut processing and exports are relatively new in Senegal, although the cashew plant has a long history in the country. Cashew is grown in five administrative regions of Senegal. Total annual production is about 26.000 tones with increasing trends. The principal growing areas are in the Casamance which lies between The Gambia and Guinea Bissau. Further production is found in the Fatick Region where the community around Sokone has developed some plantings, seemingly as a consequence of donor projects and NGO initiatives. Lastly, east of Dakar, in the Thies Region, there is further significant production.

Figure 24: Cashew production in Senegal by administrative region[93]



[93] *African Cashew Initiative, 2011, "Analysis of the Cashew Value Chain in Senegal and the Gambia".*

The value chain has a relatively simple flow with not many links. Cashew processing takes place in all three of the production areas of Senegal, in Casamance, Fatick/Sokone and Thies, with varying degrees of success.

Millet

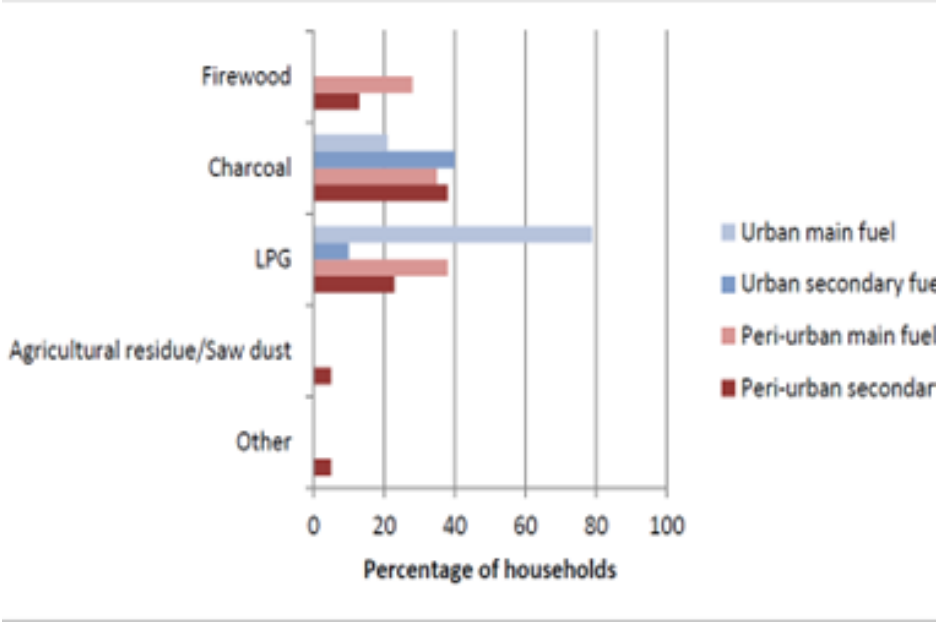
Though Senegal millet production fluctuated substantially in recent years, it tended to increase through 1971 - 2020 period ending at 1.14 million tonnes in 2020. The country has about 2.000.000 hectares under millet cultivation. Millet is a basic subsistence crop in Senegal, but farmers face low yields due to unsustainable cultivation techniques and poor quality seeds. In 2019 Senegal exported 203 tonnes of millet. Through 2019 alone, the market for Senegal millet (cereals/grains category) has increased, with a change of 45 percent compared to the year 2018. Between 2017 and 2019, millet's exports increased by 10.33% netting the country US$0.18m for the year 2019.[94]

f) Domestic energy production market in Senegal

The Senegalese energy sector is relatively small, with 27TWh/year provided by fossil fuel, thereby making 40% of Senegal's primary energy provision, which the remainder is nearly entirely biomass (over 50%)- most of which non- renewable- complemented by some coal and some hydro and solar for electricity production through renewable sources. In terms of consumption, the large biomass share in energy provision is for household cooking, either as firewood (58% of households) or after carbonisation as charcoal (26 % of households). In addition, 11% of households use LPG for cooking (mainly in bigger towns), 4% use electricity and 1% uses lampoil. The LPG share thereby is smaller than one would expect based on prevalence of LPG stoves (e.g. in Dakar, where 20% of Senegal's population lives, over 90% of households have LPG stoves) - as LPG supply is not always reliable, in which case (urban) households fall back on charcoal.

[94] *https://www.selinawamucii.com/insights/market/senegal/millet/*

Figure 25: Cooking fuels use in Senegal[95]



To cover cooking fuels needs, stakeholders use charcoal, firewood and LPG. This overwhelming reliance on traditional cooking fuels and technologies has led to adverse health, social and ecological impacts. From the mid-1970s until 2009, the Senegalese government encouraged the transition from charcoal to LPG for households through the use of subsidies and promotion campaigns and as a result, LPG is still highly available in periurban regions with a well-functioning distribution network in place. But, as the subsidies to LPG phased out since 2009, combined with an unpredictable supply market and low income levels of the population, poor households diminished their demand. Charcoal is easy to use and widely available, even in small quantities, matching the buying patterns of poor households. Nevertheless, its price is highly variable depending on the season and the transport costs associated. Firewood is mostly used as a backup during shortages of LPG or charcoal and a cooking fuel for traditional meals in traditional stoves. However, the use of firewood results in the highest emission levels of any of the fuels, causing serious health impacts. Peri-urban households in have to purchase most of their firewood rather than collecting it (as is done in rural areas).

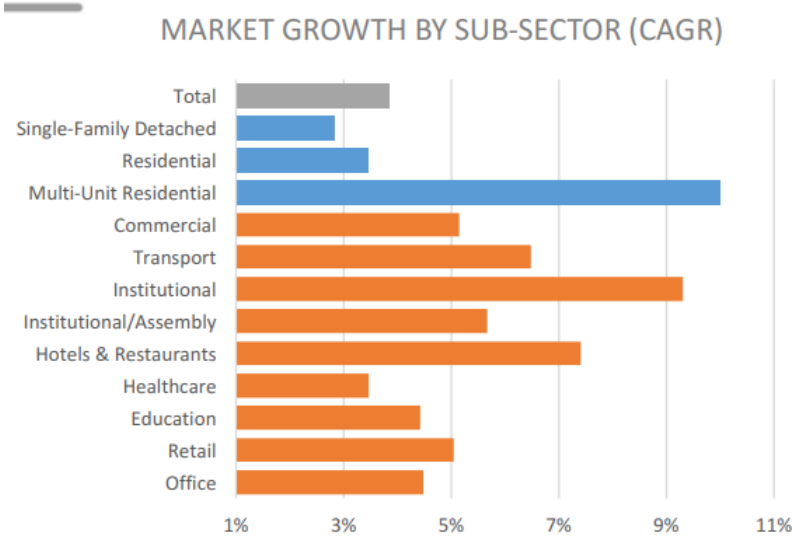
Construction sector in Senegal

The building sector in Senegal is growing by 3.9% per year, propelled by economic growth and rapid urbanization. The country holds a 3.8% urbanization rate and taking into account also that 43% of the population resides in urban areas, demand for affordable housing is and will remain strong. The demand for housing is estimated at 300.000 units per year, while supply is 50.000, creating a deficit of 250.000 units. Regarding expected market growth by sub- sector, residential will be driven by multi-unit residentials, growing at around 10% and hotels and restaurants above 7%.[96] Migration from the countryside has expanded

[95] *World Bank, 2014: Baseline and feasibility assessment for alternative cooking fuels in Senegal*
[96]*https://www.peeb.build/imglib/downloads/B%C3%A2timent_et_%C3%A9nergie_au_S%C3%A9n%C3%A9gal_%E2%80%93_Analyse_PEEB.pdf*

the population of urban areas and resulted in slow dying out of earthen architecture, due to concrete becoming more popular as a building material.[97, 98]

Figure 26: Market growth of the construction sector in Senegal[99]



While dynamic, the real estate market still faces a housing deficit, as there is insufficient supply of housing resulting from limited availability of serviced land, few financial products, high construction costs, and poor-quality housing. Key constraints for the development of services and real estate sectors are high informality due to the uneven regulatory environment, access to finance, and poor urban infrastructure in secondary cities.[100]

The most used material in construction is cement. Yet, despite the presence of three cement plants whose product is used in nearly 70% of constructions, the costs are high in Senegal. This is also largely due to secondary materials, which are imported and account for 50% of costs. Thatch/straw is more common in rural areas, with 33.42% of households use it as the main construction material for the roof of their home. There are four main categories of eco-materials in Senegal: land, typha, straw and bamboo. Each of these materials is locally present and used in traditional construction or pilot projects (including typha). Laterite (a sedimentary mixture, is also used throughout the country and excavated in open-air quarries. Earth is used as a raw material in the manufacture of mud bricks or compressed earth brick (BTC). [101]

[97] *https://www.britannica.com/place/Senegal/Housing*
[98] *https://www.bbc.com/news/av/business-55138292*
[99] *https://www.peeb.build/imglib/downloads/B%C3%A2timent_et_%C3%A9nergie_au_S%C3%A9n%C3%A9gal_%E2%80%93_Analyse_PEEB.pdf*
[100] *https://www.ifc.org/wps/wcm/connect/e1527ea2-910e-49f2-8f60-0d484a296688/CPSD-Senegal-v2.pdf?MOD=AJPERES&CVID=ngN-Dig*
[101] *PEEB, (2021): "Batiment et energie: Analyse du secteur du batiment au Senegal: Synthese et recommendations", available at http://www.peeb.build/imglib/downloads/Synth%C3%A8se_B%C3%A2timent_et_%C3%A9nergie_S%C3%A9n%C3%A9gal_PEEB.pdf*

Customers segments

The following customer segments have been identified for the several BIO4AFRICA outputs in the Senegalese use case. Each customer segment is characterized by specific needs and a relatively different capacity to exploit BIO4AFRICA outputs.

- **Smallholder farmers and rural households:** 95% of Senegal farmland consists of small family farms , which have an average cultivated land size less than 5ha%[102]. Approximately 70% of Senegal's agricultural holdings constitutes 33% of the cultivated land area.[103] Senegal's main agricultural areas are situated in the regions of Thiès, Diourbel, Fatick and Kaolack, the latter two being cut through by the bassin arachidier (groundnut basin). Small holder farmers cultivate millet, sorghum, maize and rice for subsistence purposes. Livestock contributes to the livelihood of around 30%of Senegalese households. Pastoralists and agro-pastoralists mainly raise cattle, sheep and goats; their participation in the meat market is marginal. Most Senegalese rural households are involved in traditional (that is, small-scale) poultry raising. The majority of these smallholder farmers lack access to high-quality seeds, fertilizer, machinery, climate information, market access and financial services, thereby with limited potential to increase yield and income. Access to and efficient use of fertilizers by this group is essential to replenish soils and boost production.

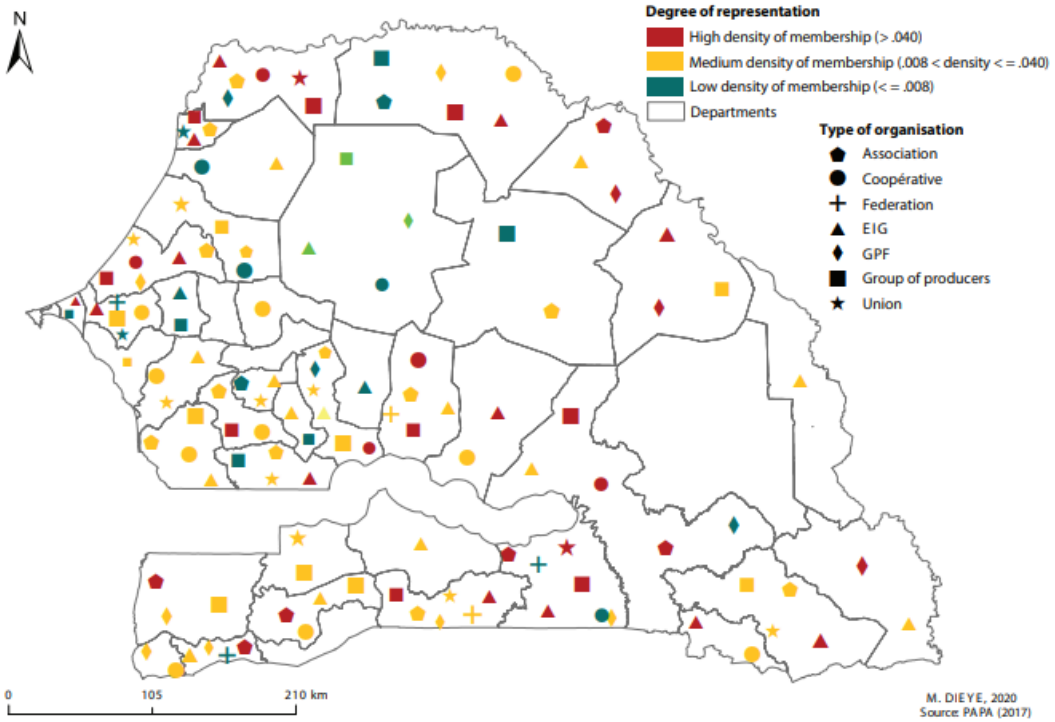
- **Women organizations and Women Promotion Groups:** Local community organizations are the key stakeholders in defending women's rights, promoting women's leadership and advancing gender equality in Senegal. Additionally, there is a growing number of Senegalese women 'promotion groups' (Groupements de Promotion Feminine or GPFs), promoted by the government and development organizations (more than 6800 with over a million members [104] . The aim of GPFs is to bring together self-employed women from the same community to share interests. The involvement of such organizations in the BIO4AFRICA activities is expected to significantly contribute to the adoption of the proposed outputs, and in particular to the use of biochar as cooking fuel and soil amendment.

- **Commercial agricultural operators:** Well-established commercial agricultural infrastructure in Senegal is based around Dakar, with some big companies such as SANDIMA and NMA Sanders.

- **Farmers collective entities and producer organizations:** In Senegal, a peasant movement exists with a vast number of rural institutions in thousands of villages as well as strong national-level farmer organizations. At the national level, it is estimated that 17% of smallholders are members of an organization, with the lower percentage (9%) being for producers of dry cereals and higher rates of membership observed to producers of horticultural crops, mainly located in the coastal north and irrigated rice farms in the south (38% and 33% respectively).

[102] *https://climateknowledgeportal.worldbank.org/sites/default/files/2019-06/SENEGAL_CSA_Profile.pdf*
[103] *World Bank, 2014: Baseline and feasibility assessment for alternative cooking fuels in Senegal*
[104] *https://www.iied.org/can-promotion-groups-help-strengthen-womens-access-control-over-land*

Figure 27: Producer organizations in Senegal[105]



Source: Data from Projet d'Appui aux Politiques Agricoles survey, Senegal (2017).
Note: EIG = economic interest group; GPF = groupement de promotion feminine (women's advancement group).

By type, membership in Economic Interest Groups is most common, mostly for irrigated rice and horticulture producers. The activities of organizations vary among: buying of inputs, labor provision, water management, sales of outputs, transport, packaging and storage. A general notion is that despite their long history, organizations of rural collective action in Senegal are relatively weak in delivering benefits to their members. The main obstacles are: weak design rules, heterogeneity of members and bureaucratic procedures and rules.

- **Small businesses (hotels, restaurants):** The touristic sector in Senegal is growing, combined with the rapid urbanization that the country is also facing, with the number of beds accounting for 34,062 in 2015[106] However, current installations are characterized by obsolescence that need renovation and high energy costs. For BIO4AFRICA scope, this presents a good predisposition to adopt eco-construction materials, such as bio-composites, and alternative cooking fuels, as additionally, it will contribute to upgrade the hospitality services offered and meet the expectations of international tourists increasingly looking for environmentally friendly outset.

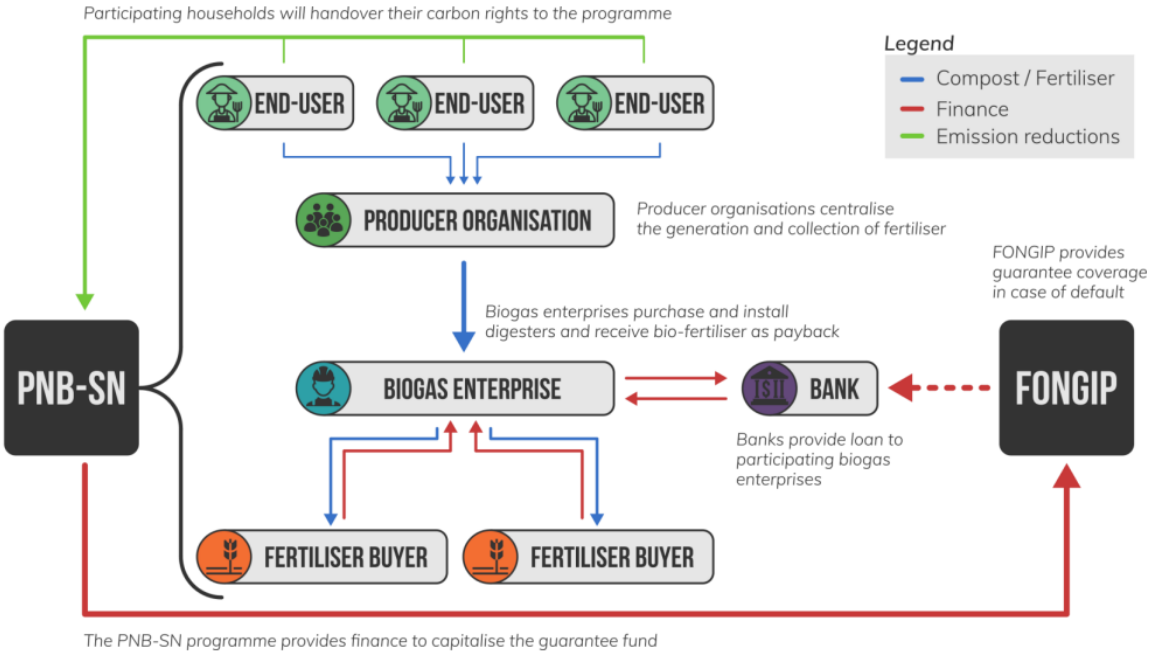
- **Biodigesters providers:** In Senegal biogas systems exist almost exclusively at small-scale level, to cover to household energy needs, particularly for cooking. The implementation of biogas digesters

[105] *https://www.resakss.org/sites/default/files/2020_ator_individual_chapters/Ch8%20ReSAKSS_AW_ATOR_2020.pdf*
[106] *PEEB, 2021 "Analysis of the building sector in Senegal"*

has been promoted by PNB (Senegal National Biogas Program). There is only a handful of prefabricated biogas technology providers. The main actors in the development of biogas technology in Senegal includecÉcole Supérieure Polytechnique de Dakar (ESP), Centre Régional Africain de Technologie, (CRAT), Centre d'Études et de Recherches sur les Energies Renouvelables (CERER), and Environmental Development Action in the Third World (ENDA Energy).

- **PNB-SN (Senegal National Biogas Program):** Since 2009, Senegal runs a national domestic biogas programme (PNB-SN) that supports the adoption of domestic biogas systems, with the objective of deploying more than 52000 biogas digesters between 2021 and 2030. It is hence the main target customer segment for the promotion of BIO4AFRICA output of biochar to be used as additive in biogas production systems.

Figure 28: PNB-SN Stakeholders and roles[107]



- **Construction companies and other professionals in the construction industry:** The use of architects and other professionals in the construction industry is very low in Senegal, except for the tertiary sector (businesses, public buildings etc.). These professionals constitute an interesting lever for the promotion of innovative materials such as bio-composites to change construction habits, more than in the residential sector, where there is a very high proportion of informal constructors.

[107] *https://www.klik.ch/resources/KliKWebcast_Blueprints_PNB1.pdf*

Value chains SWOT analysis

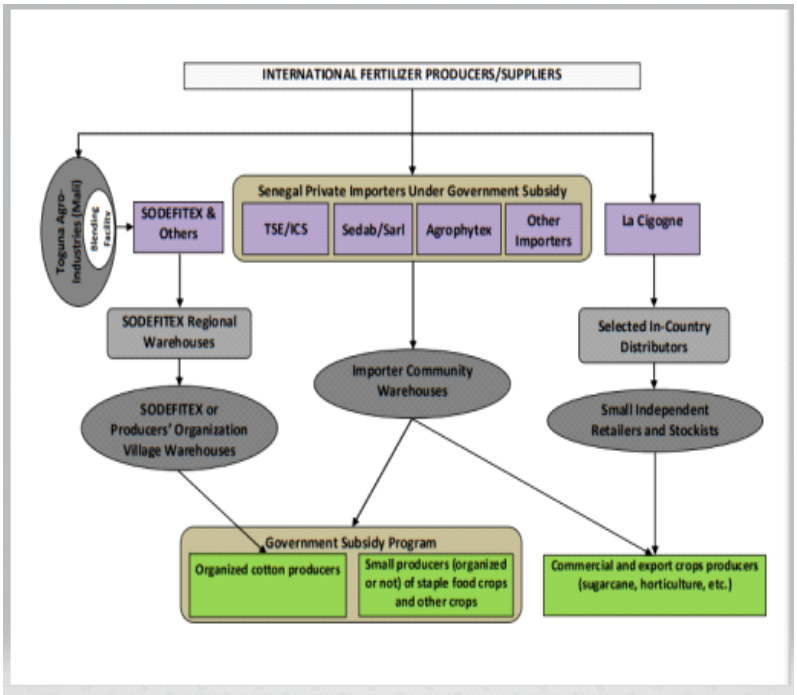
Strengths	Weaknesses
All outputs Small- scale and fit to the local context technologies of low capital and operating costs Low complexity technologies, not requiring high level of knowledge and skills (pyrolysis, briquetting, bio-composites) Valorization of agricultural waste streams Innovative, environmentally friendly outputs **Biochar as soil amendment** Improved water use efficiency Improved soil fertility, especially for sandy soils Increased crop yield Reduced nutrient loss Low-cost soil amendment Indirect reduction of other greenhouse gases through soil emissions **Biochar/ biomass briquettes as cooking fuel** Decreased deforestation pressures Increased fuel efficiency (reduction in indoor air pollution) Decreased fuelwood demand (benefits for women) Reduction of unsustainable wood harvesting Indirect sources of emissions reduction Contribution to energy transition towards	**All outputs** Lack of relevant legislation and standards Limited access to information, communication and learning mechanisms Training of farmers on the technologies is required **Biochar/ biomass briquettes as cooking fuel** Improved cookstoves that use biochar or biomass briquettes as cooking fuel are needed Education of women to enhance adoption is required Informal supply chain for domestic cooking fuels **Biochar as soil amendment** Effectiveness of biochar use as soil amendment is highly dependent on biochar synthesis, soil and crop types and quantities applied.
Opportunities	**Threats**
Create business opportunities for local fuel providers and intermediaries Certification of biochar (IBI Biochar Certification Program) Use of biochar for restaurants or hotels Combine local feedstocks with urban green wastes, biogas digestate, manure etc.	Potential negative health impacts of handling biochar Low adoption from the local population Lack of long-term policy framework for supporting new energy systems Competition between different uses of residues to be used as feedstocks (rice husk)

generating new waste management business opportunities Set up standardization procedures for biochar in collaboration with the Senegalese Standardization Agency (ASN)	Marginalization of vulnerable groups due to development of "ownership" of biomass on a local basis. Inadequate after sales service Limited access to spare parts in the local markets

Level of competitiveness

- **Fertilizer producers:** The fertilizer market in Senegal is the sixth largest in West Africa and it is essentially intended for groundnuts, grain crops (mainly rice and corn), horticultural crops, cotton and sugarcane production. Senegal is producer of rock phosphate and phosphoric acid and ICS and SERPM have production plants for phosphate fertilizers and conduct exports. But most fertilizer consumed in the country, especially nonphosphate sources, is imported to be blended with those locally produced. For many years, the provision of fertilizer was dominated by ICS and SENCHIM, governmental institutions created for fertilizer production and distribution, being also the only institutions authorized to import and distribute fertilizer through other domestic companies, most of which were part of the SENCHIM distribution network. After 2005, the sector started to become privatized, with an accreditation system created for companies wishing to import and distribute fertilizers. The non-subsidized fertilizer market is relatively small, focusing mainly on sugarcane and horticultural products, and it cannot easily compete the subsidized products in terms of prices. The fertilizer distribution structure, along with the main market players is presented in Figure 29below

Figure 29: Fertilizer distribution structure in Senegal[108]



[108] *https://africafertilizer.org/wp-content/uploads/2017/04/The-Fertilizer-Supply-Chain-in-Senegal.pdf*

- **Charcoal commercial agents:** The charcoal value chain is complex and at a great degree informal, with a wide range of operators with varying interests and stakes. Charcoal is primarily produced in forest areas close to urban centers. The production is mainly batch type through earth or mound carbonization kilns of low efficiency. Charcoal producers typically package charcoal in bags and then the charcoal is transported through various means to urban centres, depending on the local situation. Charcoal producers are often contracted by wholesalers or transporters, but they also work individually. Most of the charcoal is sold to large- or small-scale transporters, some of them also being wholesalers. The last pass the charcoal on to smaller-scale retailers and consumers. For the majority of the operators across the value chain, charcoal does not offer a high income. Yet, urbanisation and population increase lead to ever increasing charcoal demand, and the economic importance of the charcoal sector is substantial, especially for women.
- **LPG providers:** The sector has multinational companies (such as TOTAL and VITOGAZ), as well as independent local companies (such as Touba Gaz) distributing LPG to the wholesale outlets. The wholesale outlets supply to the retailers, who then supply to the end-users. The wholesalers specialize in the sale of LPG through gas plant facilities, while the retailers are those with shops and stores, not exclusively selling LPG. The bulk of the LPG consumed in Senegal is imported, due to low local production capacity.
- **Ecomaterials market players:** The BTC construction sector in Senegal revolves around a limited number of actors with a temporary monopoly situation . Indeed, the dynamic demand coupled with a simple and easy to implement construction system and a relatively well distributed network suggests the emergence of strong competition in the coming years. Main market players: ElemenTerre, the main player in the filiere, The GIE Presse Ta Terre, French company Eiffage have already experimented and participate in the realization of pilot buildings in BTC

Potential collaborators

The valorization potential of different agricultural waste streams that BIO4AFRICA solutions offer create different forms of collaboration among stakeholders. Based on the results of Task 1.2 of BIO4AFRICA, value-added commercial opportunities on the targeted agricultural waste of BIO4AFRICA Senegalese case include:

- Processing of cashew nuts by-products (e.g., split, broken cashew kernels) that is directly provided to commercial markets, without prior processing.
- Use of cashew nut shells for energy generation.
- Collect and use rice straw as animal feed on the spot or to semi-intensive livestock farms.
- Collect and use rice straw as organic input on farms.
- Collect and use rice milling by-products (e.g., husk) as organic input on farms

Additionally, the following actors have been identified as potential collaborators for BIO4AFRICA outputs rollout in Senegal.

- **Cashew nut and peanuts processing companies**
- **Africa Biochar Partnership:** Open continental platform for advancing the use of biochar systems in Africa (Biochar Plus and Biochar for Sustainable Soils projects). The overall objective of the Africa Biochar Partnership is to harmonize the coordination, communication and capacities building of biochar systems as opportunities for optimized biomass and bio-waste use towards improved resource management in the sectors of agriculture, environment, energy, health and socioeconomic development of the African people.
- **Organizations working on Sustainable Buildings and Construction in Africa** (Emerging Africa Infrastructure Fund (EAIF), International Council for Research and Innovation in Building and Construction (CIB), African Union for Housing Finance, The Sustainability Institute, Promoting Renewable Energy in AFRICA (PREA), Construction Industry Development Board (CIDB)

3.4.3 Market conduct analysis

Competitive rivalry within the market

Biochar is produced on a small scale and in small quantities in Senegal, for smallholders use. Barrel reactors are more often used for this purpose. Biochar produced is used mainly as a soil amendment but also for water filtration.

The briquetting fuel sector in Senegal is in its infancy, with a relatively limited number of technologies in use by only a couple of producers (BRADES, BIOTERRE), while some other companies that had been involved in the sector have ceased production. Regarding biogas, the main actors in the development of biogas technology in Senegal include École Supérieure Polytechnique de Dakar (ESP), Centre Régional Africain de Technologie (CRAT), Centre d'Études et de Recherches sur les Energies Renouvelables (CERER), and Environmental Development Action in the Third World (ENDA Energy).

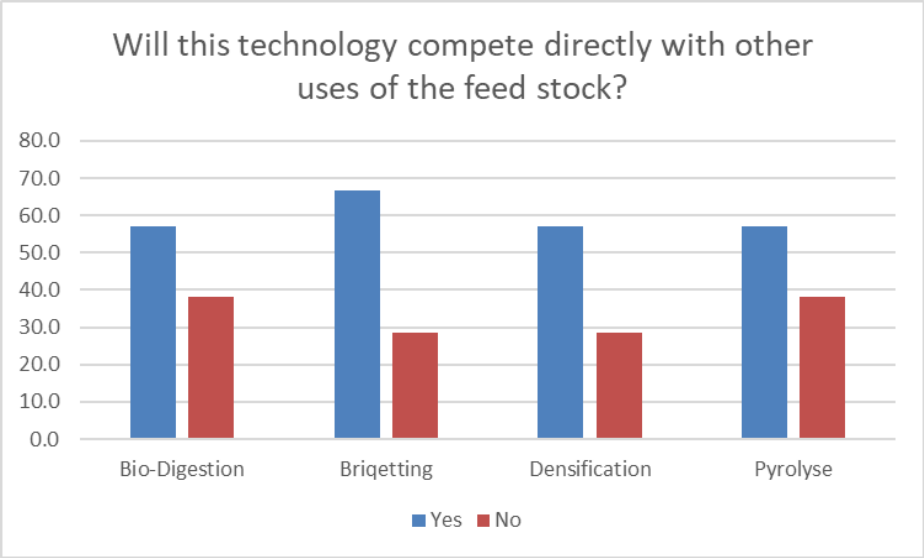
To maintain soil fertility, chemical fertilizers are generally applied, most of them being imported, except from phosphate that is mined in the country. However, nutrient use efficiencies are rather low in Senegal and chemical fertilizers are very expensive to the small-holder farmers and sometimes difficult to find available in the market. In general, farmers are more willing to pay more for the fertilizer to be used on more valuable crops, such as specific varieties of groundnuts, rice maize and millet rather than the tree crops such as mango,

Regarding biogas production systems, in small-scale biogas digesters no additives are used for the time being. The same applies to bio-composites, which use in the market is non existent at the moment.

As resulting from Task 1.4 of BIO4AFRICA, in Senegal, over 50 % of the stakeholders (55% bio digestion, 65% briquetting, 55% densification and 55% pyrolysis) indicated that the technology will compete with other uses of the feedstock. Some of the uses quoted included some of the proposed feedstocks are used as feed food for livestock, Typha is used for house construction and some of the feedstocks are used as fertilizers.

37%, 27%, 27% and 35% of the stakeholders seemed to agree that there will be no competition with other uses of the feedstock for bio digestion, briquetting, densification, and pyrolysis respectively.

Figure 30: Competition with other uses of feedstock in Senegal[109]



The threat of new market entrants

The potential for new cooperative consortia with interested investment parties could be of the utmost importance for the new market entrants. Several barriers to entry are discussed below, focused only on the outputs of: biochar as soil amendment, biochar and biomass briquettes as cooking fuel. The use of biochar as additive in biogas production systems and the production of bio-composites has been considered as out of the scope of this particular paragraph, as both applications are still at an early stage of research with no direct footprint in the national market.

- **Loyalty to existing competitive products:** Regarding the use of biochar as soil amendment, biochar projects in developing countries have the potential to be economically viable. Nevertheless, the economics of these ventures is largely dependent on the effectiveness of biochar to address the specific local soil fertility constraints, the duration of duration of biochar's agronomic effect, the biochar application rate, and the value of the crops to which biochar is applied. BIO4AFRICA entails several research and adaptation, piloting, validation and business activities on the production and use of biochar as soil amendment in the target countries, with the aim to reveal how feedstock properties and operating conditions affect the quality of soil amendment produced and how the economics are determined. This should be considered as a major unique selling point of our solutions compared to possible new entrants. As far as the use of biochar and biomass briquettes for cooking fuel is concerned, Briquettes tend to be cheaper than charcoal, while improving cooking time. However, despite the potential benefits of, and opportunities for, the use of alternative fuels in the region – particularly briquettes –little awareness of them currently exists: Raising awareness and accelerator activities that are planned under BIO4AFRICA offer a major advantage compared to possible new entrants.

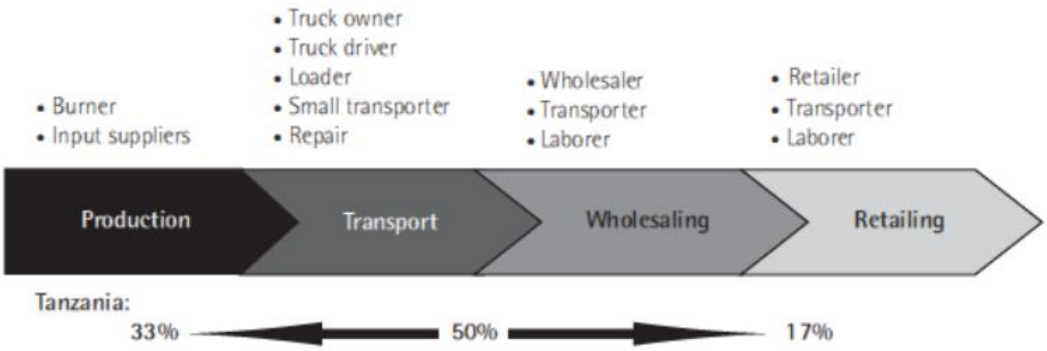
[109] *Sedi, M., Kyalo, W. D., & Marechera, G. (2021). Diversifying revenue in rural Africa through circular, sustainable and replicable biobased solutions and business models - D1.4: Co-definition of technologies to be transferred with local farmers and communities.*

- **Cost advantages and capital requirement:** BIO4AFRICA technologies target a priori the local micro and small scales, i.e. those of household and farmer respectively, that appear to be suitable to the Western Africa context, in terms of feedstock availability and biochar end-uses. Indeed, these scales seem to be relevant both in terms of feedstock available, i.e. the agricultural waste from farms, and of char end-uses, i.e. cooking fuel in houses, which seems to be the short-term priority, or also soil improving material in farms or gas/water treatment at the exit of digesters located either in farms or houses. The technologies adapted and transferred will be robust, flexible, easy to use and cheaper than larger ones, in terms of investment, and operating costs.
- **Government regulations:** There is not a specific legislative or standardization framework related to biochar and biomass briquettes.
- **Access to suppliers and distribution channels**: Although biomass or biochar briquettes sector is in its infancy in Senegal, it should be noted that the availability of potential feedstocks is quite large. Existing players in the supply chain of charcoal could take advantage of the existing supply chains (collection of feedstock, distribution and retailing of briquettes)

Economic relationships within markets

All targeted markets in Senegal case for BIO4AFRICA share smallholder farmers and households as main stakeholders. Regarding the charcoal market, the main competitive product to biochar to be used as cooking fuel, the structure of its value chain and distribution of profits is depicted in Figure 31below:

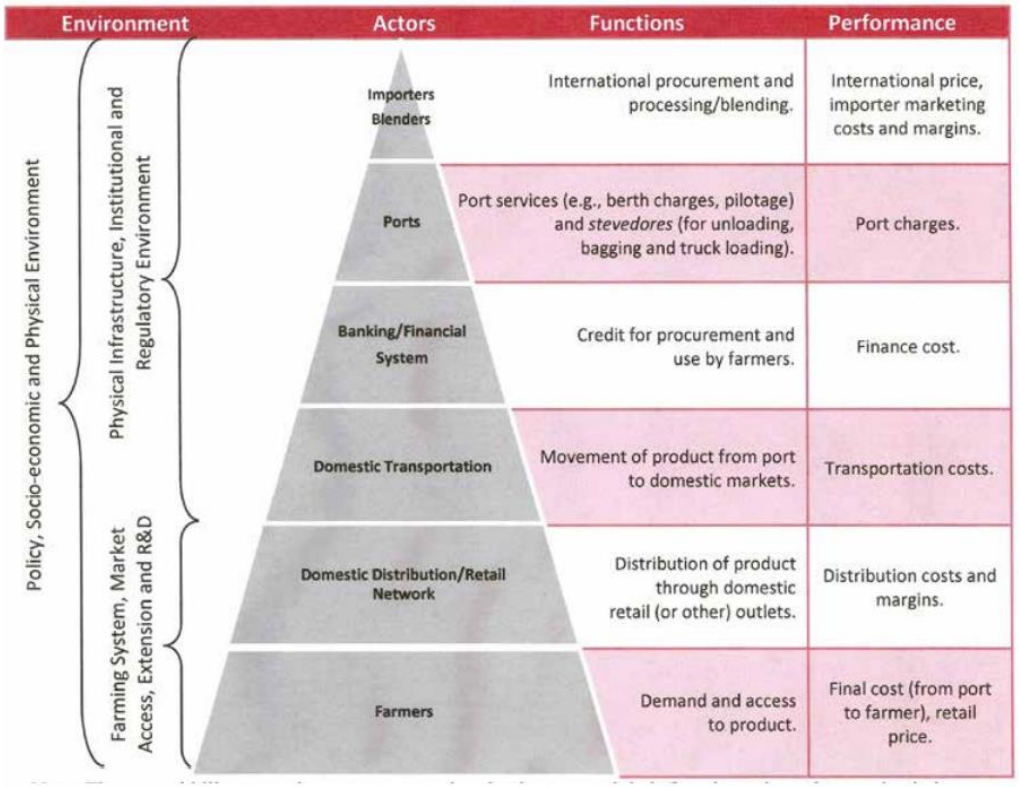
Figure 31: Distribution of profits along the charcoal value chain[110]



The domestic fertilizer supply chain with the main cost structure and functions across is presented in the Figure 32 below:

[110] *https://english.rvo.nl/sites/default/files/2013/12/Report%20Charcoal%20-%20BTG%20-%20NPSB_0.pdf*

Figure 32: Cost structure, involved actors and their functions along fertilizer supply chain in Senegal[111]



Patterns of commercial behaviour

Prices and commercial activity for these agricultural residues exist but, as it is not frequent and the producers rather use them for their own needs, the prices are not fixed and are agreed in negotiation between producer/ buyer under personalized circumstances. The farmers independently determine the prices even if other products are not sold. The price for cashew shells is 25,000 FCFA per ton of biomass at SOCOCIM

Fertilizers have subsidized by the government, having about half of the price compared to non-subsidized products. The total subsidies for Senegal is 72,6 M, where 30% is allocated to fertilizers. There were government-approved and registered tenders for the subsidized fertilizers and the farmer purchased the remainder of their fertilizer through the private market. Farmers were responsible for obtaining their fertilizer from the suppliers' warehouses, and 80% of the fertilizers on the market are government approved tenders. Yet, farmers often face situations of limited access to the recommended mineral fertilizers, as the latter are generally not sufficiently available in sufficient quantities, especially for urea. When the Government of Senegal ceased giving subsidies for chemical fertilizer (mainly phosphate fertilizers), many small-scale farmers lacked the resources to purchase it on the open market.

Regarding solid fuels traditionally used as cooking fuels or for other domestic uses, prices vary a lot depending on production locality. The price of one kilogram of wood can range from 200 to 250 FCFA and small vans (tricycle motor) filled with firewood can cost up to 5 000 FCFA. There are great price variations from one area to another. The market of charcoal in Senegal is liberalized, and in the absence of government regulation,

[111] *https://africafertilizer.org/wp-content/uploads/2017/04/The-Fertilizer-Supply-Chain-in-Senegal.pdf.*

charcoal is often sold at inflated prices defined by the sellers. These price changes usually affect the poorest households. For example 250 F CFA for 1 kg of charcoal and 3 500 F CFA for a bottle of butane gas in Ziguinchor. From the mid-1970s until 2009, the Senegalese government encouraged the transition from charcoal to LPG for households through the use of subsidies and promotion campaigns. However, the relatively low income levels, combined with the progressive withdrawal of the governmental LPG subsidy and an unpredictable supply market, have all had a detrimental effect on their LPG consumption levels.

Regarding the role of women during the decision-making processes taking place in farm operations, as revealed in BIO4AFRICA Task 1.1 activities[112], most of respondents agreed that those opinions and advice coming from women are considered when having to reach consensus on crucial operations: determine the type of crop to grow for that season, direct selling of certain vegetables and grains such as papaya and cashew nut. This was a more common practice having place in family-owned businesses, where the role of women is also linked to plan and set household budgets.

3.4.4 Market performance analysis

Bargaining power of customers

Regarding biochar to be used as soil amendment, the bargaining power of small-holder subsistence farmers is relatively low, as they do not have the necessary cash or access to credit in order to buy fertilizers (even in the case of part subsidized ones). Commercial farmers are well aware of the benefits of fertilizer use and they comprise the main fertilizer market outside the subsidy program. Their bargaining power becomes higher as long as they form in agricultural cooperatives or collective entities, in order to put prices downward. Such farmers organizations of the most valuable crops (cotton, peanuts etc) in local and national level act for the procurement of agricultural inputs.

The same situation applies to poor households, to whom biochar to be used as a cooking fuel appeals. Their disadvantaged economic situation deteriorates their negotiation potential. The bargaining power becomes greater for collective organizations, such as women groups etc.

Bargaining power of suppliers

The major by-products of rice are rice husk and rice straw. Much of the rice straw is burned on site before cultivation- due to difficulties from removing it from the field. In other cases, it is either left in the field for grazing of cattle or buried into soil to improve soil fertility. Thus, the tonnages of rice straw also varies considerably depending on the regions and harvesting techniques used. The feed value of rice straw varies from year to year, depending on the varieties grown, cultural practices, dates and harvesting methods. In rice production farmers are recommended to not export the straw outside the field to increase the availability of the potassium, nonetheless, most do not follow this recommendation. In the Senegal River Valley, 80% of the rice straw residues are burned. A reason for the burning of rice straw is that cattle are wandering around rice fields, releasing their dung in the fields. As dung contains seeds, cattle are seen as a major vector for dissemination of wild rice (which is considered as weed). The remaining 20% of the rice straw residues are either fed to animals or buried in the field as fertilizer. A different situation happens in the Casamance region, where almost no rice straw is burned. The residues are either left in the field for grazing

[112] *Garcia, M., Sedi, M., & Willy, D. (2021). BIO4AFRICA - Diversifying revenue in rural Africa through circular, sustainable, and replicable biobased solutions and business models - D1.1: Contexts and needs of African rural communities.*

or the straw is buried to improve soil fertility. times of drought, biomass may be very limited, and nutrition is a major concern in cattle production in Senegal. All rice residues fed to livestock compete with soil fertility. Alternatively, farmers could use rice straw for energy. There is no evidence that rice straw is used as energy source in Senegal

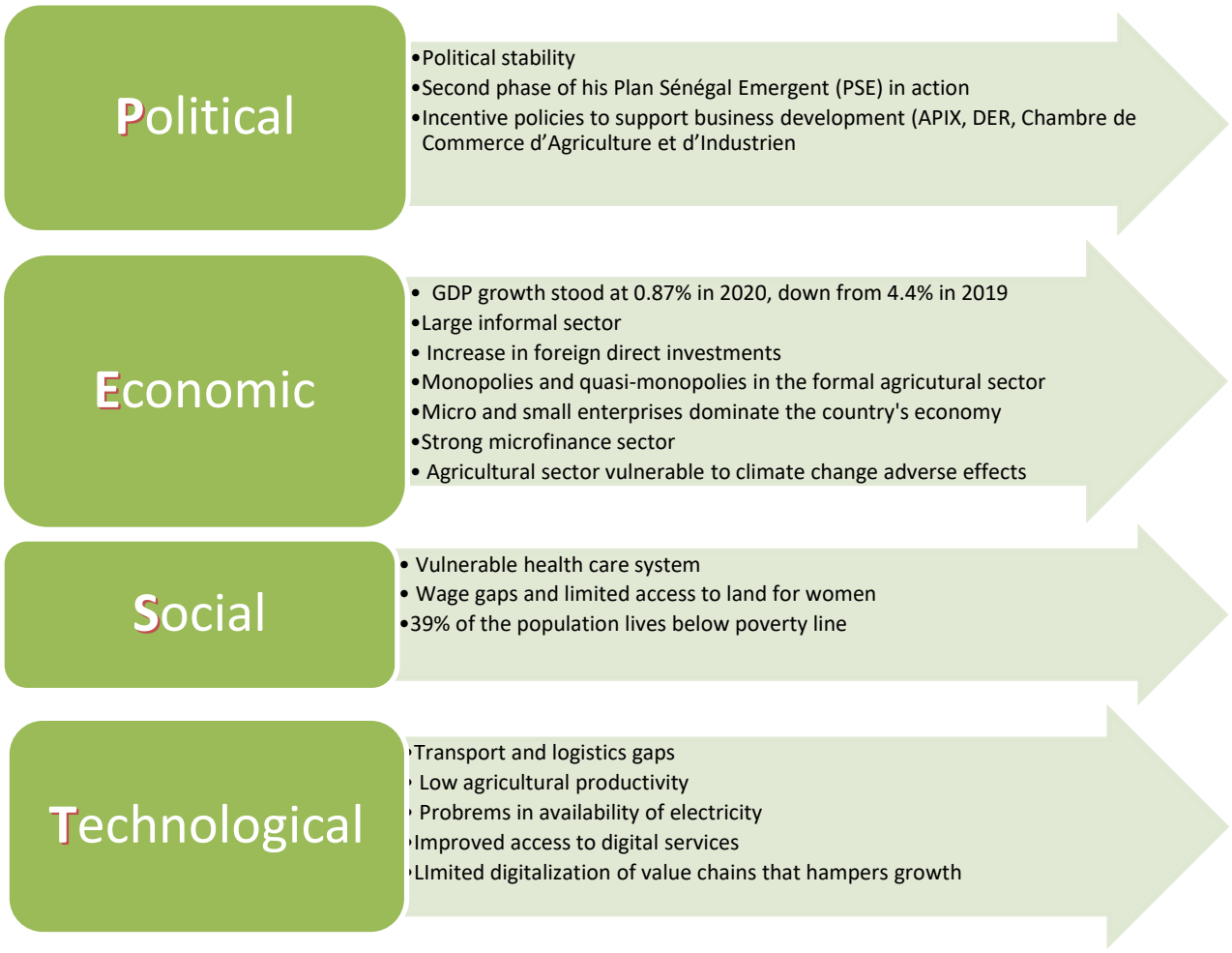
Peanut shells are traditionally used as organic matter by farmers to restore their paddy fields affected by salinity. In addition, positive effects of peanut shells on yield of millet and corn on salty soils were observed in Senegal. Peanut processing companies might use them as a fuel for peanut roasting, but in most cases, they are not used productively, being left to accumulate next to processing facilities, or are burned in the fields. Hence, the potential to use residues for a productive task is enticing. There are also some projects producing briquettes from waste peanut shells to be used as solid fuel. Peanut shells are also used as animal feed for breeder sheep, and they are highly sought for this purpose. For peanut shells, the bag is sold at 500 FCFA and can go up to 1,000 FCFA in other areas.

Cashew shells have not been valorized as a general practice in Senegal. In some large cashew processors, such as SCPL, SOCOCIM and SONACOS, cashew shells are used to feed the boiler to produce steam for cooking cashew nuts or to produce heat for drying almonds.

Millet and maize stalks are used for fencing houses or fields or as feed for animals but in general, the degree of their valorization is small.

All the above mentioned agricultural residues, that are meant to be used for BIO4AFRICA case in Senegal are very easy to find, taking into account each crop seasonality, and can be stored for marketing purposes, in particular corn straw, rice husks, peanut shells. As Senegalese agriculture is characterized by small-holder farming, production is not aggregated in large producers at the moment, with the exception of rice husk, peanut shells and cashew shells. An important factor determining their ease of access is the proximity to the production place. The possible distribution channels are the transporters and the traders, with the farmers being the most disadvantaged.

PEST analysis



Trends, growth prospects & potential socio-economic impact.

Senegal's current challenge is to mitigate the socioeconomic impact of the pandemic while enabling sustainable and inclusive growth. This will require[113]:

- Improving resilience to macro-fiscal, environmental, climate change, and social risks to safeguard investments in human capital and household livelihoods;
- Boosting and protecting human capital for productivity growth.
- Enhancing competitiveness and job creation by improving digital and physical connectivity at the national and regional levels and increasing the efficiency of labor markets.
- Lowering energy costs, reducing the carbon footprint, and optimizing the energy mix.
- Promoting the services economy and boosting the productivity and competitiveness of agriculture and related value chains.

The agricultural sector in Senegal is vulnerable, as it is mainly directed by family farms, practicing substistence agriculture and about 75% of the population is highly dependent on rain fed agriculture. Additionally, the need for mechanization is significant as there is a short time frame between harvest and sowing. Yet, Senegal

[113] *https://www.worldbank.org/en/country/senegal/overview#1*

has the opportunity to blaze path for decentralized, small-scale, urban and rural food production using regenerative agricultural practices. The focus is on the promotion of agricultural and rural entrepreneurship based on the existence of agribusiness and family farming. For processing, it will take into account all aspects related to products and by- products, both processed by the agri-food industry and by traditional means.

4. Conclusions and next steps

All BIO4AFRICA technologies and outputs constitute potential novel business solutions with outputs that the local populations are not familiar with due to their innovative character but answer to basic local needs. Greeen biorefinery and biochar production technologies are new to the focus countries. The level of competition in all relevant market segments is low, as well as the threat of new entrants and the BIO4AFRICA outputs provide significant opportunities for income diversification, through fit to the local context implementation schemes.

Livestock includes ruminants (sheep, goats etc), pigs, poultry and other species (snails, rabbits etc) and it is a promising sub-sector for increase in the future in Ghana. The same promising pattern is highlighted in the marine fisheries sub-sector following the increasing consumption trends, but the introduction of aquaculture is immature at the moment, developing a dubious investment field for potential stakeholders. The Ghanaian market regarding the need for animal feed and soil amendments is expanding since the real growth rate of agriculture as a whole is increasing. Nevertheless, Ghana faces a variety of coordination problems among farmers, processors, and industrial end-users. This is not the only problem between the value chains links, but local policy implications with potential stakeholders hinder the development of value chains in the country. BIO4AFRICA outputs in Ghana could provide significant benefits to local communities and farmers, with major strengths their low-cost, infrastructure, adaptability to local conditions, robustness and low complexity. Their use would provide an opportunity to diversify farmers' income, take advantage of local feedstocks and create new job opportunities, as long as access to information, communication and education on the introduced technologies is ensured and after sales support is guaranteed.

Despite the pandemic's impacts, Uganda is expected to face one of the highest economic growth rates in 2021 of 6.3%, in comparison with other African countries. Livestock is a very important factor for many families in the country, in order to optimize income, improve social status and contribute to food security. The agricultural production mix of Uganda includes an assortment of crops mainly for home consumption, though exports have increased by 20% between 2018 and 2019. BIO4AFRICA technologies to be tested in Uganda are with low capital and operating costs and with low complexity and focus on selected local forage species, based on the indigenous knowledge of local farmers and communities, providing high availability of animal feed alternatives during all seasons with increased nutrient concentration for several animal species. Main weaknesses that have to be faced for paving out the road to business exploitation of BIO4AFRICA outputs in Uganda are the need to build capacity on proposed technologies uses, to educate farmers in order to enhance adoption and combat competition with established trade networks, as far as soil amendments are concerned.

Cote D' Ivoire is one of the rapidly- growing countries in Africa, with an average growth rate of over 7% from 2012 to 2020. Agriculture plays a leading role in national economy being the engine of economic growth, accounting for 16% of GDP and employing two-thirds of the population. BIO4AFRICA focuses on the use of agricultural byproducts of main productive crops that have a strong export character as well. Livestock rearing plays a key role in the economics of Cote D' Ivoire as meat consumption, particularly chicken meat, is increasing fast. Additionally, 35% of the rural population in Cote D' Ivoire struggles to access clean water.

BIO4AFRICA technologies and outputs to be tested in Cote D' Ivoire are fit to the local context and needs of local farmers, processors and population in terms of improving soil fertility, give access to low cost animal feed throughout the year and improve drinking water safety. Additionally, they provide the opportunity to

exploit agricultural waste streams that in most cases remain unvalorized with economic and environmental benefits. Inadequate and expensive logistics infrastructures and possible resistance in adoption of the proposed solutions by the local population should be considered as important threats to be taken into account for the business rollout of the project solutions in the country.

95% of Senegalese agricultural land is worked by very small-scale family-based farms engaged in subsistence agriculture. Despite agriculture's importance in national economy, the sector is negatively impacted by land access problems, irregular rainfalls, poor soils, deterioration of forests and water resources (in quality and quantity). BIO4AFRICA focuses on agricultural by-products stemming from the main productive crops (rice, ground nuts, cashew nuts, millet etc.) and with low competition of other uses. Regarding domestic energy use, there is overwhelming reliance on traditional cooking fuels such as firewood and charcoal that has led to adverse health, social and ecological impacts. The building sector in Senegal is growing by 3.9% per year, propelled by economic growth and rapid urbanization. BIO4AFRICA proposed outputs in the Senegalese case study answer to the vital need to improve soil fertility and subsequently crop yields through easy to access and cheap soil amendment material (biochar), to get access to a low cost and environmentally and socially friendly alternative cooking fuel (biochar). At the same time, bio-composites and biochar as additive in biogas digesters provide an excellent opportunity for new, innovative business activities in sectors with low to non-existent competition. As in other BIO4AFRICA focus countries though, attention should be paid on providing adequate awareness raising, capacity building, and training activities to local population so as to enhance adoption of the newly introduced technologies and also to ensure after sales service and support.

In the next steps in BIO4AFRICA activities, business models will be co-designed through a participatory process with local communities and stakeholders. Utilising the Triple Layered Business Model Canvas, local workshops for alternative value propositions will be implemented, followed by the design of the business models for each pilot site and the analysis of the necessary strategic partnerships to stimulate the knowledge transfer toward farmers (Task 5.2). Furthermore, these business models will be tested and validated in a real-life context using the Minimum Viable Business Models (MVBs) and financial plans will be developed for investments in forage agri-food systems leveraging suitable available models of funding and finance already identified (Task 5.3). Additionally, the business potential of the business cases for the bio-based technologies will be thoroughly examined from both the point of the farmer (entrepreneur) and the case itself. On one hand (farmer's view), business plans per pilot case will be developed, including Go-to-market strategy, Cash flow statement, Profit and loss and Balance Sheet statement, and on the other hand, a technology business plan will be developed based on the inclusive and sustainable business models co-designed, tested and validated previously, to ensure the alignment with local market contexts (Task 6.3). Eventually, circular business practice guides will be elaborated; these guides will be comprised of: (i) a business model assessment guide, (ii) a business plan development guide as well as (iii) a funding guide, with a view to supporting the successful replication of the BIO4AFRICA paradigm in other regions across rural Africa (Task 6.4).

APPENDIX I: Indicative support material for workshops and interviews

Concept note

Overview of the

Workshop Concept note
Implemented under Task5.1

DATE

21 January 2022

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101000762.

BIO4AFRICA

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1. RATIONALE

Africa will need to feed 1.2 billion people by 2030 and over 2 billion by 2050 and, almost 20% of Africa's population is affected by undernourishment. Additionally, 60% of sub-Saharan African land is used for grazing animals, and many people combine crop farming with livestock production, which is crucial for livelihoods across the continent. Livestock is a valuable asset for rural communities, pulling power for ploughs and transport, creating income diversification via nutrient-rich animal products, as well as being key to reclaiming degraded land and conserving soil integrity and water.

BIO4Africa will contribute to Africa's food and nutritional security by combatting poverty, while driving inclusive and sustainable rural development. Furthermore, BIO4Africa will support the deployment of the bioeconomy in rural Africa via the development of bio-based solutions and value chains with a circular approach to drive the cascading use of local resources and diversify the income of farmers.

The ultimate focus is on transferring simple, small-scale, and robust bio-based techs adapted to local biomass, needs and contexts, including green biorefinery, pyrolysis, hydrothermal carbonisation, briquetting, pelletising, bio-composites, and bioplastics production.

In doing so BIO4Africa aims to empower farmers to sustainably produce a variety of higher value bio-based products and energy, including: animal feed, biochar, biocomposites, bioplastics that can be used as fertilisers, pollutant absorbents, construction materials, packaging, solid fuel for cooking, and ingredients for biogas production. These uses significantly improve the environmental, economic and social performance of their forage agri-food systems. BIO4Africa has set up four pilot cases with eight testing sites in Uganda, Ghana, Senegal and Cote d'Ivoire, offering more than 300 farmers and farmer groups, including small dairies and lower-income farmers, women farmer groups and transhumant pastoralists, the opportunity to test them in real productive conditions.

Under this overall context, BIO4AFRICA aims to provide rural communities with diverse options for taking up the bio-based solutions into their agri-food systems using bio-based business models that are sustainable. It will do so, by employing analytical and design tools well-fit for sustainability-oriented business models and deploying participatory activities to co-design, test and validate these models alongside rural community stakeholders (farmers, bio-based experts, extension services, development partners, local authorities, policy makers, etc.).

2. SCOPE OF THE BIO4AFRICA TASK 5.1 WORKSHOPS

The Work Package 5 concerns the development and assessment of circular, replicable and sustainable business models and has as a goal to thoroughly assess their potential along with their investment requirements, with a view to using the insights uncovered, to provide hands-on business support (awareness raising, business training, mentoring, access to finance support) as well as circular practice guides for rural entrepreneurs to uptake these techs and animate their own business models.

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In this way, Task 5.1 "Analysis of novel bio-based value chains and markets in rural Africa" , aims to analyse the prospective markets and value chains to be formed via the pilot cases of the project in Uganda, Ghana, Ivory Coast and Senegal combining gender-sensitive market and value chain analyses.

The analyses will follow the "structure – conduct – performance" model and will include:

(i) Market structure analysis:

The analysis (Following Porter's framework) will look into suppliers, buyers, product substitutes, barriers to entry and competitive rivalry for each industry involved and it will be based on data generated from the value chain analyses (WP1) and a series of Market Scenario Workshops.

(ii) Market conduct analysis:

The analysis seeks to identify the economic relationships (vertical and horizontal) characterising each market and explore the potential patterns of commercial behaviour (e.g. buying and selling practices, pricing behaviour, etc.). It will be based on the findings of the market structure analyses, that will be validated and complemented via interviews with experts as well as value chain actors in the regions where the pilot cases and their testing sites will be situated.

(iii) Market performance analysis:

The analysis will leverage the knowledge generated by the previous analyses of this task in order to assess the value chains based on crucial aspects such as size, prices, trends, growth prospects and value added. It will also reflect on the gender dimension and relevant socio-economic implications such as the potential to contribute towards the diversification of farmers' income, fostering rural women's empowerment and entrepreneurship, creating employment opportunities as well as alleviating poverty.

The BIO4AFRICA TASK 5.1 workshops are implemented under (i) Market structure analysis. Discussions in these workshops will be made regarding to critical success factors and limitations of the markets and their potential for fostering inclusive opportunities and empowering rural communities and further emphasis will be given to women and vulnerable groups.

3. COMPOSITION OF THE BIO4AFRICA TASK 5.1 WORKSHOPS

The BIO4AFRICA TASK 5.1 workshops will look into suppliers, buyers, product substitutes, barriers to entry and competitive rivalry for each industry involved, thus multi-disciplinary experts (from a regional, industry and technology perspective) will be invited to discuss on critical success factors and limitations of the markets as well as their potential for fostering inclusive opportunities and empowering rural communities, from organizations such as:

- Advisory bodies;
- Executive government and administration as well as legislative bodies;
- Civil Society Organisations (CSOs), Non-Governmental Organisations (NGOs), and consumers associations;
- Academic and educational institutions;

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- Research centres, cooperative research networks and knowledge transfer organisations;
- Farmers;
- Farmers' asssociations;
- Technology providers;
- Agricultural advisors;
- Authorities (representatives of agricultural management); and
- Environmental engineers.

10 – 15 participants are expected to participate in each workshop that will be organised for the needs of each pilot case of the project, and in particular in Uganda, in Ghana, in Ivory Coast and in Senegal.

The participation to the co-creation workshops does not require any form of preparation on the side of the participants. Still, it typically makes for a better event experience when participants are aware of what to expect as well as what benefits they stand to gain from their participation in the workshop.

4. STRUCTURE OF THE WORKSHOPS

4.1 Invitation process

As soon as each country partners fix the date of their workshop, it is strongly suggested to inform the members of their respective stakeholders via e-mail in order for them to be aware and save the date for the event. This save-the-date e-mail can include some basic information (date, time, duration and even an agenda if already available). A more informative invitational e-mail can follow in due time when the details pertaining to the organisation of the workshop are fixed. Country partners are encouraged to consult with Q-PLAN in case they would like support in preparing their save-the-date and/or invitational e-mails.

4.2 Supporting material, digital tools and facilitation

We suggest that country partners engage at least 3 people from their organisation to act as:

- **Moderator**: Coordinating the live event, moderating discussions and keeping activities on-time.
- **Facilitator**: Facilitating the use of the computers, presentations and the digital tools used for keeping notes, ranking, etc.
- **Rapporteur**: Keeping notes during discussions and activities, being responsible for reporting.

Familiarise all people involved in the implementation of the workshop with the flow and tools to be used in its framework. We strongly encourage to organise a rehearsal meeting with your team members in preparation for the workshop to simulate its implementation and ensure that everything works as intended.

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If a country partner finds it useful, a broad array of online platforms along with digital collaboration tools can be used to organise and better run the workshops. A few indicative tools are provided in the table that follows.

Tools	Description	Link
Miro	Online collaborative whiteboarding, library of templates, integration with web apps, good for brainstorming, sticky notes, freeform pen, shapes, arrows etc.	https://miro.com/
Mentimeter	Online platform to Build beautiful interactive presentations, Collect polls, data and opinions from participants using smart devices and Get insights on participants with trends and data export	http://www.mentimeter.com/
Mural	Sticky notes, text, shapes and connectors, icons, frameworks, images, gifs, Drawing	https://www.mural.co/

4.3 Implementation

The first half of the workshop will be devoted to the implementation of the Task1.4 workshop, whereas the second half of the workshop will be devoted to the implementation of the Task5.1 workshop.

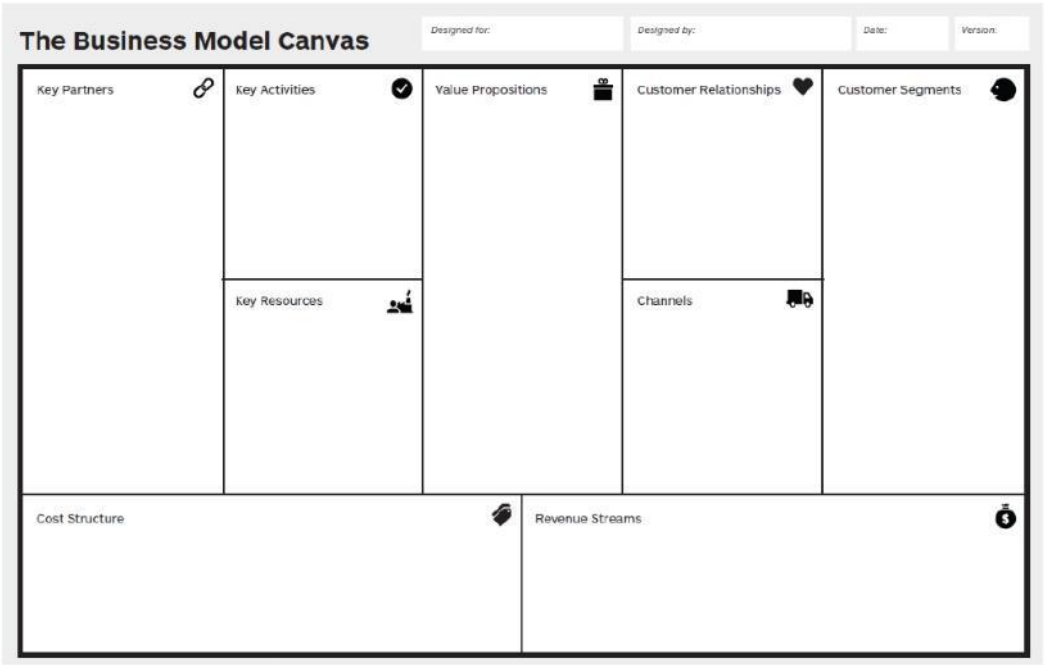

Figure 1: BMC that will be designed for selected technologies in each country

In order to identify properly the newly created business models for BIO4AFRICA after the implementation of the technologies developed in the project, the basic principles of the Business Model Canvas (BMC) tool will be utilized. This tool reflect the state-of-the-art in business modelling and is popular amongst entrepreneurs and businesses. For an illustration of the BMC elements, see Figure above.

More specifically, based on the BMCs completed for each technology in each country, the following questions will be addressed:

a) Which are the characteristics that play the most crucial role in the market structure?
b) Which are the factors that shape business strategy in the sector? (Threat of entry to the market from other organisations, Supplier power, Buyer power, Availability of substitute products, Existing competitors)
c) In which technologies is each factor more evident?

4.4 Dated action plan

A brief action plan for the organisation, implementation and reporting of the regional workshops is provided by the table which follows. It is imperative that the plan is carried out on time as, building upon the co-

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creation results of these workshops, we will inform the implementation of the project's European co-creation workshop and ultimately successfully submit the respective deliverable (D1.6) to the European Commission.

Action	Who	When
1. Fix the date of each workshop and invite participants 2. Share the agenda and invitation of the workshop with Task leaders	Local partners	04/02/2022
Elaboration and sharing of workshop specific guidelines and reporting	Q-PLAN	15/02/2022
Organise workshop (including rehearsal meetings beforehand to safeguard successful implementation)	Local partners	28/02/2022
Complete the workshop reporting and send it to Q-PLAN	Local partners	15/03/2022
Analysis of workshop results and integration within the deliverable	Q-PLAN	31/03/2022

Table 1: Action plan for the organisation of workshops

5. OVERVIEW OF THE BIO4AFRICA MARKET STRUCTURE ANALYSIS

5.1 Framework for analysis

As mentioned above, the work of this task is based on Porter's framework on the five forces that shape an industry competition. This is a framework (Porter, 1985) for diagnosing an industry structure, and which is built around five competitive forces. According to Porter, these forces erode long-term industry average profitability. In general, the framework can be applied at industry level, the level of strategic group or even at the level of an individual firm. Through it, we can explain the sustainability of profits against bargaining and against direct and indirect competition.

Porter's five forces (https://www.ifm.eng.cam.ac.uk/research/dstools/porters-5-forces/), or factors that shape business strategy are (shown in the exhibit):

- Threat of entry to the market from other organisations
- Supplier power
- Buyer power
- Availability of substitute products
- Existing competitors

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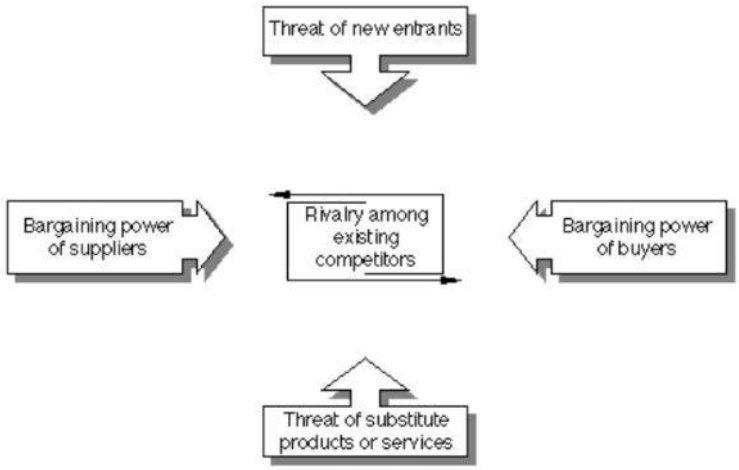

Figure 2: Porter's five forces

Barriers toEntry

- Economies of scale (Supply-side and Demand-side)
- Customer Switching costs
- Capital requirements
- Access to distribution channels
- Government policy
- Expected retaliation

Power of Suppliers

- Differentiation of inputs
- Switching costs of suppliers and firms in the industry
- Presence of substitute inputs
- Supplier concentration
- Importance of volume to supplier
- Cost relative to total purchases in the industry
- Impact of inputs on cost or differentiation
- Threat of forward integration relative to threat of backward integration by firms in the industry

Determinants of Buyer Power - Bargaining Leverage

- Buyer concentration versus firm concentration
- Buyer volume
- Buyer switching costs relative to firm switching costs

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- Buyer information
- Ability to backward integrate
- Substitute products
- Pull-through
- Price Sensitivity
- Price / total purchases
- Product differences
- Brand identity
- Impact on quality / performance
- Buyers profits
- Decision makers' incentives

Rivalry Determinants

- Industry growth
- Fixed (or storage) costs/value added
- Intermittent over capacity
- Product differences
- Brand identity
- Switching costs
- Concentration and balance
- Informational over complexity
- Diversity of competitors
- Corporate stakes
- Exit barriers

Determinants of Substitution Threats

- Relative price performance of substitutes
- Switching costs
- Buyer propensity to substitute

Eventually, the five forces reveal how the profitability is what it is in the industry and can provide data for the incorporation of these conditions into businesses strategy. Through the identification of these forces, a baseline for sizing up strengths and weaknesses of companies are provided. The understanding of the structure of the industry can provide managers with proper guidance in view of what are the strategic actions need to be made, in order to better cope with the forces; anticipate and exploit any possible shifts; and promote the creation of a new structure by shaping how these forces balance.

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5.2 Prerequisites for the market structure analysis

In order to gather the proper information and data for the market structure analysis, other Work Packages from the project will contribute and more specifically, WP1.

In the Task 1.2, mapping of the local agri-food systems will be implemented with the aim is to get deeper insights into the main features of their local forage agri-food systems, while also highlighting their dynamics and revealing pathways for sustainably introducing bio-based value chains. Available feedstocks, actors, processes, resource flows, and value chains of the project's pilot cases will be included in the task deliverable, whereas value chains will be broken down into different stages (e.g. on farm, supply chain, retail, consumer, etc.). Identification of the systems' boundaries and processes as well as the value chain characteristics will also be included in the procedure. A high-level representation of agri-food forage systems and the detailed individual mapping for each case are included in the deliverable.

In the Task 1.3, a catalogue of technologies with potential for being successfully adapted and transferred to different contexts across rural Africa will be delivered. These technologies will be classified by (i) scale (farm, village, community, etc.); (ii) technological readiness level; and (iii) market deployment level (incl. important non-technical deployment barriers, if any).

In the Task 1.4 a comprehensive multiperspective view of the needs and contexts of our focal farmers and communities (T1.1), their value chains (T1.2) and the screened bio-based technologies driven by our partners (T1.3), will be compiled. A cost-benefit analysis will be conducted and the alternative full chain biomass-to-products business cases, that could be piloted in Uganda, Ghana, Ivory Coast and Senegal, will be defined. Eventually, the report will include: (i) the methodology and findings of the synthesis exercise; (ii) results of the workshops along with the technologies to be adapted and transferred to each case; and (iii) specifications and guidelines on how the technologies could best be developed and adapted to meet the identified needs, contexts and opportunities of each case.

5.3 References

Ostwerwalder A. and Pigneur Y. (2010). Business Model Generation. New Jersey: John Wiley&Sons Inc.

Porter, M. E. (1980). Competitive strategy: Techniques for analyzing industries and competitors. The Free Press.

Porter, M. E. (1985). Competitive advantage: Creating and sustaining superior performance. The Free Press.

Porter, M. E. (2008). The five competitive forces that shape strategy. Harvard Business Review, 86(1), 79–93. https://hbr.org/2008/01/the-five-competitive-forces- that-shape-strategy

Wanyonyi E. I., E. W. Gathungu, H. K. Bett & D. O. Okello | (2021) Determinants of Porter's competitive strategy utilization among agro-dealers in Kenya, Cogent Food & Agriculture, 7:1, 1865595, DOI: 10.1080/23311932.2020.1865595

https://www.ifm.eng.cam.ac.uk/research/dstools/porters-5-forces/

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6. VALUE OF THE BIO4AFRICA SOLUTION FOR AFRICAN FARMERS

In order to demonstrate the value of the BIO4AFRICA solution for African farmers, BIO4AFRICA foresees the elaboration of a business plan for sustainable small-scale bio-based entrepreneurial ventures for each of the pilot cases.

More specifically, these Business plans (from the farmers point of view) will include:

(i) a Go-to-market strategy: Evidence-based marketing strategies will be formulated in terms of future trends and market segments, positioning strategies and target customers will be defined and, finally, a valid marketing mix will be produced.

(ii) a Cash flow statement: It will reflect the way each business model spends (outflows) or brings money (inflows from investments, on-going operations, etc.).

(iii) a Profit and loss (P&L) and Balance sheet (BS) statement: It will summarise the revenues, expenses and costs incurred, and will providea information about the ability (or not) to generate profit and value by increasing revenue, reducing costs or both. The BS provides a basis for computing rates of return and evaluating the venture's capital structure also disclosing a snapshot of what it owns and owes.

(iv) a Self-evaluation of the economic, environmental and social sustainability: A sustainability report will be prepared for each case. The report will assist stakeholders to assess and communicate their economic, environmental, social and governance performance, and manage possible issues or changes more efficiently.

The overall objectives are to analyse the needs and contexts of the rural communities along with their agri-food systems and value chains to drive the evidence-based adaptation and transfer of tailored bio-based solutions and in parallel, co-design, test and validate sustainable business models, all while delivering hands-on business support services and tools to facilitate their adoption and replication in rural African areas.

Report template for the workshop

Workshop Report
Implemented under Task5.1

DATE

22 February 2022

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101000762.

BIO4AFRICA

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1. Description of your Workshop

BIO4AFRICA representatives (name and organization)	Write here
Event venue	Write here
Date	Write here
Key organizational contact (name)	Write here
Work package	WP5
Task number	T5.1

BIO4AFRICA

2. Agenda

(please insert here the final agenda)

3. Promotional and publicity material

(please insert here any social media posts made, webpages or other links shared prior or after the meeting, any photographs from the workshop excluding faces of participants)

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4. Main Discussion Points - Knowledge & Insights expressed/gathered

Please use a separate box for each question addressed: identify the 'Phases' of Development that were considered and the sectors represented. In case that some question had common answers, you could merge the cells.

Will the proposed products and technologies increase the existence of already existing market players?	
Write here	
Any consensus points? (Points/advice/perspectives agreed by all stakeholders. Add lines if needed.)	
Write here	Write here
Write here	Write here
How easy will it be for farmers to use the proposed products and technologies?	
Write here	
Any consensus points? (Points/advice/perspectives agreed by all stakeholders. Add lines if needed.)	
Write here	Write here
Write here	Write here
How easy it is for new businesses to access distribution channels?	
Write here	
Any consensus points? (Points/advice/perspectives agreed by all stakeholders. Add lines if needed.)	
Write here	Write here
Write here	Write here
Are there favorable policies for starting a new business?	
Write here	

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Any consensus points? (Points/advice/perspectives agreed by all stakeholders. Add lines if needed.)	
Write here	Write here
Write here	Write here

What is expected to be the reaction of well-established agribusinesses in the market by the entrance of new players and products?
Write here

Any consensus points? (Points/advice/perspectives agreed by all stakeholders. Add lines if needed.)	
Write here	Write here
Write here	Write here

Do the suppliers depend heavily on the market?
Write here

Any consensus points? (Points/advice/perspectives agreed by all stakeholders. Add lines if needed.)	
Write here	Write here
Write here	Write here

Do the suppliers offer a variety of differentiated products?
Write here

Any consensus points? (Points/advice/perspectives agreed by all stakeholders. Add lines if needed.)	
Write here	Write here
Write here	Write here

Who are the users/ target groups of the products?
Write here

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Any consensus points? (Points/advice/perspectives agreed by all stakeholders. Add lines if needed.)	
Write here	Write here
Write here	Write here
What is the market concentration for each target group?	
Write here	
Any consensus points? (Points/advice/perspectives agreed by all stakeholders. Add lines if needed.)	
Write here	Write here
Write here	Write here
Will the proposed products represent a major fraction of the buyers income?	
Write here	
Any consensus points? (Points/advice/perspectives agreed by all stakeholders. Add lines if needed.)	
Write here	Write here
Write here	Write here
Will the proposed products and technologies be easily adopted by target groups?	
Write here	
Any consensus points? (Points/advice/perspectives agreed by all stakeholders. Add lines if needed.)	
Write here	Write here
Write here	Write here
Are there substitutes for the proposed products and technologies?	
Write here	
Any consensus points? (Points/advice/perspectives agreed by all stakeholders. Add lines if needed.)	

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Write here	Write here
Write here	Write here

How much is it expected for the proposed products and technologies to create more substitutes in the market?
Write here
Any consensus points? (Points/advice/perspectives agreed by all stakeholders. Add lines if needed.)

Write here	Write here
Write here	Write here

How much are the products standardized or undifferentiated?
Write here
Any consensus points? (Points/advice/perspectives agreed by all stakeholders. Add lines if needed.)

Write here	Write here
Write here	Write here

Who are the main market players?
Write here
Any consensus points? (Points/advice/perspectives agreed by all stakeholders. Add lines if needed.)

Write here	Write here
Write here	Write here

What is the competition landscape regarding these products?
Write here
Any consensus points? (Points/advice/perspectives agreed by all stakeholders. Add lines if needed.)

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Write here	Write here
Write here	Write here
How much equal in size and power are the competitors? Are the competitors numerous or are roughly equal in size and power?	
Write here	
Any consensus points? (Points/advice/perspectives agreed by all stakeholders. Add lines if needed.)	
Write here	Write here
Write here	Write here
How fast is the industry growing or expected to grow after the introduction of the novel products and technologies?	
Write here	
Any consensus points? (Points/advice/perspectives agreed by all stakeholders. Add lines if needed.)	
Write here	Write here
Write here	Write here

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5. Participants perspectives & comments

Additional to those recorded above. Free text area – please include your additional comments, if any.

Write here

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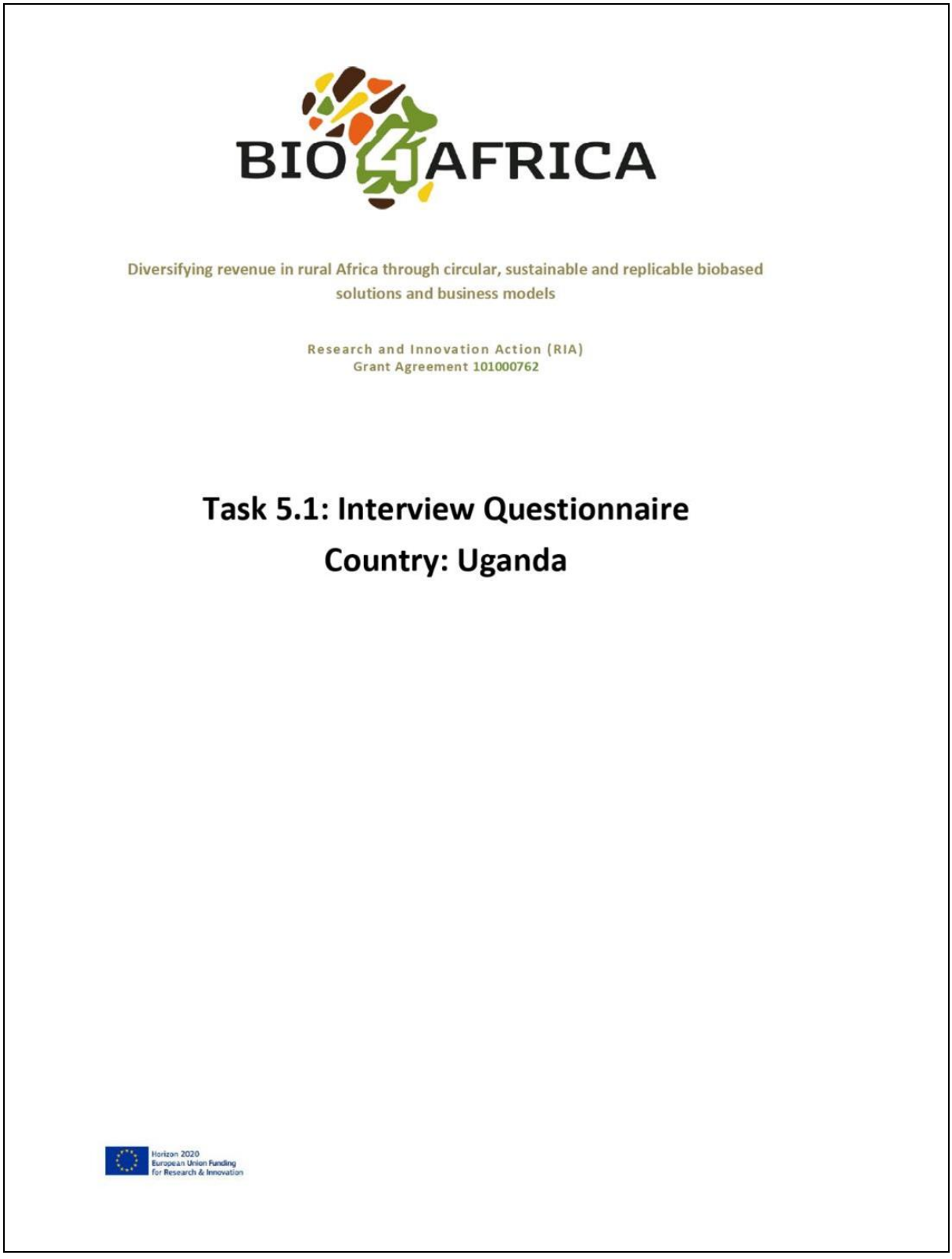
6. Participants

Please write down the overall number of participants, participants for each function (ie. Farmer, agribusiness consultants, officials) or / and body they represent. Add rows if needed and delete the examples in the cells below.

Overal Number of participants	(number here)	
No of participants	Function	Representation
2	Farmer	n/a
1	Official	Ministry of Agriculture

Interview Questionnaires



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Diversifying revenue in rural Africa through circular, sustainable and replicable biobased solutions and business models

Research and Innovation Action (RIA)
Grant Agreement 101000762

Task 5.1: Interview Questionnaire

Country: Uganda

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101000762.

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1. Questions on feedstocks to be used

Availability and fluctuation of productivity for forage species (Mucuna, Alfalfa, and Tithonia)

Write here

Competing uses for these forage species (Mucuna, Alfalfa, elephant grass and Tithonia) – in what activities are they used and what type of products?

Write here

Are the forage species traded among households and/or merchants?

Write here

Are there other possible distribution channels?

Write here

What determines the price of these forage species when traded?

Write here

Is it possible to store them and use them during the dry season? Is this practice something common by the majority of households or only by a small percentage of people?

Write here

Alternatives and competitive animal feed products for ruminants, pigs and poultry?

Write here

Is there any environmental or safety legislation regarding the exploitation of these forage species?

Write here

2. Questions related to biochar to be used as soil amendment

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Is there any biochar produced in the country? Which systems are used? Is there a market?
Write here
Other projects implemented in the past on biochar and/or soil amendments?
Write here
Is there any relevant legislation?
Write here
In which crops will we test biochar as soil amendment?
Write here
What alternatives do stakeholders have? How easy and cheap is it to access them?
Write here
Market of soil amendments (or natural fertilizers) in the country?
Write here
Who are the main players in the market of soil amendments and/or natural fertilizers? How equal in size are they?
Write here
Do all producers have equal access to the distribution channels of such products? Which stakeholders could be potentially favored?
Write here

Diversifying revenue in rural Africa through circular, sustainable and replicable biobased solutions and business models

Research and Innovation Action (RIA)
Grant Agreement 101000762

Task 5.1: Interview Questionnaire

Country: Ghana

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101000762.

BIO4AFRICA

1. Questions on feedstocks to be used

Availability and fluctuation of productivity for forage species (Panicum maximum, Guinea grass, Andropogon guyanus, Leuceanea, Albizia, Centrocema pubescence, and Stylosanthes hamata)
Write here
Competing uses for these forage species (Panicum maximum, Guinea grass, Andropogon guyanus, Leuceanea, Albizia, Centrocema pubescence, and Stylosanthes hamata)
Write here
Are the forage species traded among households and/or merchants? Are there other possible distribution channels?
Write here
What determines the price of these forage species when traded?
Write here
Is there any environmental or safety legislation regarding the exploitation of these forage species?
Write here
Do all stakeholders have equal access to the distribution channels? Which stakeholder could be potentially favored?
Write here

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2. Questions related on aquaculture

How easy is to find these local forage species (Soybean husk, Cowpea husk, Cassava peels, Maize bran)?
Write here
Are there any bio-refinery industries in the area? Availability of protein concentrate.
Write here
Competing uses for the local forage species
Write here
Is there any legislative framework and/or restrictions in relation to the use of feed in aquaculture?
Write here
Alternatives for aquaculture feed (prices, types, quantities)
Write here
Which is the level of implementation of aquaculture? (household, farm, community etc.
Write here

BIO4AFRICA

3. Questions related to biochar to be used as soil amendment

Is there any biochar produced in the country? Which systems are used? Is there a market? Other projects?
Write here
What kind of stakeholders are we aiming at?
Write here
What alternatives do these stakeholders have, if not to use biochar as soil amendment? How easy is it to find these alternatives? Determinant factors for supply?
Write here
Is there a relevant market? Which are the main players? (companies)? How equal in size are they? Is there a market growth or trend?
Write here
Is there any relevant legislation?
Write here
In which crops will we test biochar as soil amendment?
Write here
How easy is to find these agricultural by-products (Rice husk, Groundnut husk, Corn cobs, and Maize Stalks)?
Write here
What alternatives do stakeholders have? How easy and cheap is it to access them?
Write here
How easy could be for existing soil amendment producers to also produce biochar to be used as soil amendment?
Write here

Diversifying revenue in rural Africa through circular, sustainable and replicable biobased solutions and business models

Research and Innovation Action (RIA)
Grant Agreement 101000762

Task 5.1: Interview Questionnaire

Country: Senegal

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101000762.

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1. Questions on feedstocks to be used

Competing uses of: peanut shells, cashew shells, rice husk, millet and corn stems. How are these agricultural byproducts been disposed of or used right now?
Write here
How easy is to find these agricultural by-products? Are there any big producers?
Write here
Is there a price for these byproducts? What determines their price?
Write here
Are there any geographical locations within the country that are more favorable for these byproduct streams?
Write here
Is there any environmental or safety legislation regarding the use of agricultural byproducts?
Write here
How easy is the access to these agricultural by-products? Which are the possible distribution channels? Do all stakeholders have equal access to the distribution channels? Which stakeholder could be potentially favored?
Write here
Is there the possibility to store these feedstocks? Could someone buy large quantities and store, so as to achieve lower prices?
Write here
Could you please describe the mahogany fruits value chain in Senegal?
Write here

BIO4AFRICA

2. Questions related to biochar to be used as additive in biogas production systems

Who is producing biogas in the country (companies)? How equal in size are they? What is the market growth?
Write here
What kind of biogas production systems are used?
Write here
Are there any additives in biogas production systems already used?
Write here
Description of the market of biogas in the country. Private holders/ public stakeholders
Write here
Is there any relevant legislation?
Write here
Which factors affect the profitability of biogas productions systems in the country? Prices?
Write here
To whom stakeholders do the biogas production systems apply? Which needs do they cover?
Write here
What other solutions do stakeholders use to cover their needs if not biogas systems?
Write here
Which is the level of implementation of biogas systems? (household, farm, community etc.)?
Write here

3. Questions related to biochar to be used as solid fuel

Is there any biochar produced in the country? Which systems are used? Is there a market? Other projects?
Write here
Is the solid fuel that is going to be produced in Senegal pilot case going to be used only for cooking purposes? Is there another use that it could be implemented? (household/ farm/ community level?)
Write here
What kind of stakeholders are we aiming at?
Write here
What alternatives do these stakeholders have, if not to use biochar as solid/cooking fuel? How easy is it to find these alternatives? Determinant factors for supply?
Write here
How easy is to access cooking fuel/ solid fuel? Prices?
Write here
Is there a relevant market? Which are the main players? (companies)? How equal in size are they? Is there a market growth or trend?
Write here
Is there any relevant legislation?
Write here

4. Questions related to biochar to be used as soil amendment

In which crops will we test biochar as soil amendment?
Write here
What alternatives do stakeholders have? How easy and cheap is it to access them?
Write here
Market of soil amendments in the country? Main players? How equal in size are they?
Write here
Is there any relevant legislation?
Write here

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How easy could be for existing soil amendment producers to also produce biochar to be used as soil amendment?
Write here

Diversifying revenue in rural Africa through circular, sustainable and replicable biobased solutions and business models

Research and Innovation Action (RIA)
Grant Agreement 101000762

Task 5.1: Interview Questionnaire
Country: Ivory Coast

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101000762.

BIO4AFRICA

1. Questions on feedstocks to be used

Competing uses of: cassava peelings, rice husk, rubber seed, cashew nuts, soybeans. How are these agricultural byproducts been disposed of or used right now?
Write here
How easy is to find these agricultural by-products? Are there any big producers? How do they use these byproduct streams?
Write here
Is there a price for these byproducts? What determines their price?
Write here
Are there any geographical locations within the country that are more favorable for these byproduct streams?
Write here
Is there any environmental or safety legislation regarding the use of agricultural byproducts?
Write here
6. How easy is the access to these agricultural by-products? Which are the possible distribution channels? Do all stakeholders have equal access to the distribution channels? Which stakeholder could be potentially favored?
Write here

BIO4AFRICA

2. Questions related to biochar to be used as additive in water filtration systems

Who is responsible for water filtration in the country (companies/ public sector)? How equal in size are they? Is there a market? What is the market growth?
Write here
What kind of water filtration systems are used?
Write here
Which factors affect the profitability of water filtration systems in the country? Prices?
Write here
To whom stakeholders do the water filtration systems apply? Which needs do they cover?
Write here
What other solutions do stakeholders use to cover their needs?
Write here
Which is the level of implementation of water filtration systems? (household, farm, community etc.)
Write here
Is there any relevant legislation for water filtration systems?
Write here
Is there any biochar produced in the country? Which systems are used? Is there a market? Other projects?
Write here

BIO4AFRICA

3. Questions related to biochar to be used as soil amendment

In which crops will we test biochar as soil amendment?
Write here
What alternatives do stakeholders have? How easy and cheap is it to access them?
Write here
Market of soil amendments in the country? Main players? How equal in size are they?
Write here
How easy could be for existing soil amendment producers to also produce biochar to be used as soil amendment?
Write here

4. Questions related to biomass to be used for animal feed

What kind of stakeholders are we aiming at?
Write here
What alternatives do these stakeholders have, if not to use our pellets? How easy is it to find these alternatives? Determinant factors for supply?
Write here
How easy is to access animal feed? Prices?
Write here
Is there a relevant market? Which are the main players? (companies)? How equal in size are they? Is there a market growth or trend?
Write here

APPENDIX II – Photos from Task 5.1 activities


07.03.2022