Ministry of Foreign Affairs

Study of the biomass potential in Côte d'Ivoire

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Sector study

Waste-based Biomass in Côte d'Ivoire

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Study of the biomass potential in Côte d'Ivoire

Final Report

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Abbreviations

AD	Anaerobic Digestion
ANADER	Agence Nationale d'Appui au Développement Rural
ANARE	L'Autorité Nationale de Régulation du secteur de l'Electricité
BNETD	Bureau National d'Études Techniques et de Développement
CCA	Conseil du Coton et de l'Anacarde
CCC	Conseil Café Cacao
CHP	Conseil Hévéa et Palmier à Huile
CdI / CI	Côte d'Ivoire
CI-ENERGIES	La Société Côte d'Ivoire Energies
CIE	La Compagnie Ivoirienne d'Electricité
CIPREL	Compagnie Ivoirienne de Production d'Electricité
CNSL	Cashew Nut Shell Liquid
ComCashew	Competitive Cashew Initiative (GIZ programme)
CPR	Cassava Peeling Residues
CRSO	Crude Rubber Seed Oil
DDO	Distillate Diesel Oil
EFB	Empty Fruit Bunches
EKN	Embassy of the Kingdom of the Netherlands
FIRCA	Fonds Interprofessionnel pour la Recherche et le Conseil Agricoles
LHV	Lower Heating Value
MINEDD	Ministère de l'Environnement et du Développement Durable
MPEER	Ministère du Pétrole, de l'Energie et des Energies Renouvelables
Mt	Metric tonne
NBC	Noix Brutes de Cajou
PIE	Producteur Indépendants d'Electricité
PKS	Palm Kernel Shells
POME	Palm Oil Mill Effluent
RCN	Raw Cashew Nuts
RVO	Netherlands Enterprise and Development Agency
tCO_2-eq	tonnes CO_2 equivalents
toe	tonne oil equivalent

Executive summary

This study analyses the valorisation potential of biomass residues resulting from the cashew, cassava, cocoa, palm oil, and rubber value chains in Côte d'Ivoire. To this end, the availability, characteristics, and potential applications of by-products from these value chains were examined. The study draws on field research, Ivorian and Dutch stakeholder interviews, and literature review. Additionally, a local stakeholder workshop was held to validate the intermediate results. A key presumption in this study was to identify scenarios and solutions that make the most efficient use of a by-product, adding to circularity, considering local conditions and composition of the material, while making sure no competition with feed or food occurs. Environmental, economic and to some extent social impacts of utilising these by-products considered, several scenarios were identified that can be explored and developed further. Dutch knowledge and technology could play a role in the development of these scenarios.

Promising valorisation routes were identified for residues of all aforementioned value chains, including:

- Cashew nut shells: the volume of this residue is expected to increase considerably as a result of the impressive growth in processing capacity in Côte d'Ivoire. Cashew Nut Shell liquid (CNSL) can be applied as a (feedstock for) fuel. Briquettes can be produced from the shells through pyrolysis.
- Cashew apples: vast untapped (only 1% is currently used) potential resource for food, feed and energy applications. Main bottleneck to be addressed is the undamaged harvesting of the apples.
- Cassava peelings/wastewater from cassava starch production: currently poses a problem for the sector, processing into biogas or bio-ethanol can result in cost savings and emission reductions.
- Cocoa pods: currently pre-dominantly left in the field. Bio-charcoal production can result in local business opportunities and reduce deforestation.
- Cocoa bean shells: available centrally at processing plants, can be applied directly as an energy source for local industry.
- Palm Oil Mill Effluent (POME): currently causes considerable pollution issues, anaerobic treatment addresses these issues while the resulting biogas can be applied on-site.
- Rubber felling residues and seeds: rubber trees can provide good quality timber, while wood residues can be applied to produce bioenergy. Rubber seed oil can be applied to produce biodiesel.

For all these valorisation routes initiatives are ongoing, in different stages of development, including several with Dutch involvement. The recommendations of the study are geared towards new projects that can build upon and support these initiatives. Programmes of the Dutch government that could provide support are highlighted in the annexes of the report.

At a more general level, knowledge exchange and partnering activities are recommended to support the further valorisation of agricultural residues in Côte d'Ivoire:

- Valuable knowledge is available at Ivorian and Dutch universities that could contribute to optimising the socio-economic and environmental benefits of the valorisation of agricultural residues.
- Cooperation with a strong local partner is seen by many Dutch companies as a pre-requisite for business development in Côte d'Ivoire and can be facilitated by targeted match-making activities.

1. Introduction

1.1 Background

Côte d'Ivoire has a strong position among the leading economies in West-Africa in terms of electrification rate and energy infrastructure. The Ivorian government has set ambitious targets to increase the share of renewables in the total electricity mix to 42% and the electrification rate to 100% by 2030[1]. At the same time, Côte d'Ivoire is facing alarming rates of deforestation and resulting greenhouse gas emissions, fuelled by unsustainable use of biomass. Biomass plays an important role in the Ivorian energy trajectory. The projected installed power from biomass sources amounts to 485 MW.

To stimulate sustainable use of biomass and circularity[2], the government of Côte d'Ivoire intends to promote initiatives that facilitate valorisation of available resources. These resources include residues from agricultural value chains. Agricultural residues are often left untreated, which can pose environmental risk. Additionally, valorising these residue streams could create an additional source of income for farmers and/ or producers.

1.2 Purpose of the study

The purpose of this project as formulated in the ToR is "to gain insights in the opportunities and barriers for further development of the waste-based biomass sector in Côte d'Ivoire and to contribute to this development with input of Dutch expertise. Specifically, the project is focused on mapping the sustainable applications for agricultural waste in the energy sector, thereby contributing to the sustainable climate intentions of the Ivorian government".

Results of this study may inform local initiatives to strengthen the local sector. Secondly, this study aims to inform Rijksdienst Voor Ondernemend Nederland (RVO) and the Embassy of the Kingdom of the Netherlands (EKN) on opportunities for collaboration between Dutch and Ivorian sectors. Home to a strong agricultural sector and innovative biomass technology, the Netherlands is well positioned to contribute to the sustainable and productive use of agricultural residues for energy purposes, creating mutually beneficial business opportunities.

Recommendations shared in this study aim to complement existing initiatives in Côte d'Ivoire. Ongoing initiatives include the work of several NGOs and programmes initiated with co-financing of the Dutch government (e.g. initiatives led by Solidaridad, IDH and CBI). Critical to the study is to identify circular solutions that have a positive impact on environmental, social, and economic sustainability.

1.3 Study outline

The following figure shows the set-up of the study.

[1] Currently the electrification rate is 92% in urban areas and 38% in rural areas, the national overall access rate is 64% - main challenge therefore remains the electrification of rural areas.
[2] The following definition of circularity was used for this study: https://www.government.nl/topics/circular-economy/from-a-linear-to-a-circular-economy

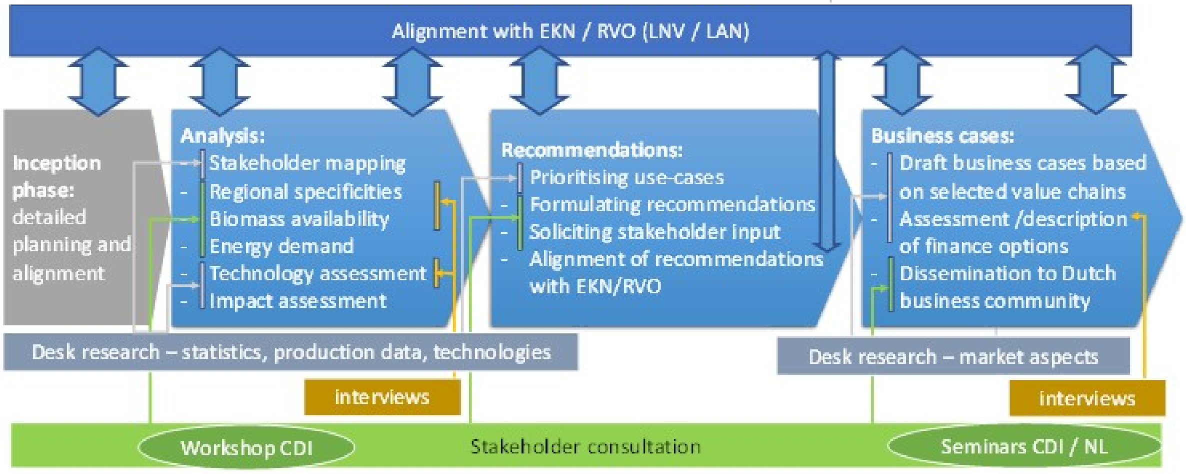

Figure 1 Overview of the study outline

The study can broadly be divided into three phases:

1. Inventory and analysis phase: Research based on stakeholder interviews, field visits, and literature review; selection of value chains, assessing availability of biomass from agricultural residues and identification of potential valorisation routes; inventory of potential sustainability risks.
2. Recommendations phase: Prioritisation of valorisation routes based on a number of parameters, including sustainability risk, logistical feasibility, maturity of technology and synergy potential with existing initiatives.
3. Communication of results to stakeholders.

1.4 Guidance for the reader

This report summarises the main results of the inventory and analysis phase. It provides conclusions and recommendations based on these results. The approach and methodologies applied are introduced in chapter 2. The subsequent five chapters detail analysis and recommendations for each of the selected agricultural value chains (chapter 3 to 7). Each of these chapters starts with a summary of the characteristics of the value chain, followed by a summary of available biomass resources and their potential applications. Further details of these aspects can be found in Annex G (Assessment of biomass potential) and H (Inventory of energy demand), which are available as separate reports. Chapter 8 provides conclusions and recommendations of the study.

2. Approach of the inventory and selection of productive use cases

2.1 Context

Currently, biomass accounts for 70% of energy consumption in in Côte d'Ivoire [bb]. Current consumption of biomass is largely inefficient, due to use in traditional cookstoves. Productive use remains limited. In recent years, several large-scale bio-energy initiatives have been initiated including a 46 MW biomass facility using palm oil waste (Aboisso, under construction) and facilities using cocoa waste (Divo region, 60-70 MW and Gagnoa, 20 MW) and cotton residues (Boundiali, 25 MW). This research focuses on stimulating this development and on identifying additional options for productive use of residue streams.

Several Ivorian universities and research institutes engage in biomass research. Among these universities are Institut de recherche sur les énergies renouvelables (IREN), Institut National Polytechnique Felix Houphouet-Boigny (INPHB), and University Nangui Abrogoua (UNA). Their research programmes cover the value chains assessed in this study.

2.2 Approach of the inventory

Selection of agricultural value chains
As part of the inception phase of the study, the scope in terms of agricultural value chains was defined in consultation with RVO and EKN. In order to optimise the longer-term potential impact in terms of valorisation of agricultural residues, starting points were to include the main cash crops in the country as well as selecting a food crop with a high potential in terms of available by-products.

According to data from the 2016 agricultural census and the 2019 statistics provided by the BNETD, cocoa, oil palm, rubber and cashew nuts are the most dominant agricultural cash crop products (Figure 2).

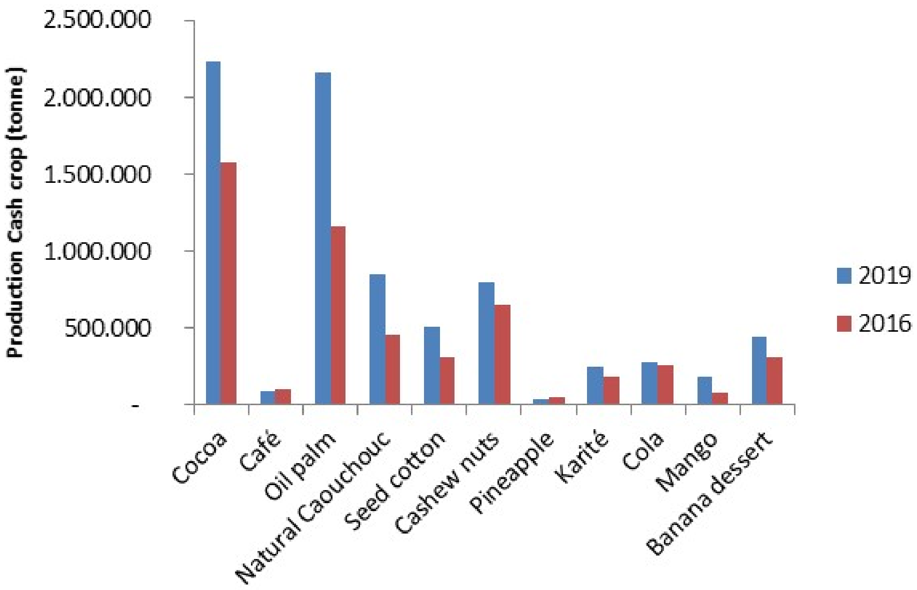

Figure 2 Cash crop production in Côte d'Ivoire (BNETD, 2020)

A report published by GIZ in 2020, titled "Partnership Ready Côte d'Ivoire: Organic Waste Management and Recycling" provides an overview of agricultural waste available in Côte d'Ivoire. The table below indicates the potential for the cocoa, cashew, oil palm and rubber value chains, which yield the main recoverable biomass volumes. Food crops such as cassava and yam (with respective productions of 5.877.000 and 7.450.000 tonnes (2019)) also represent considerable resources of agricultural residues. The scope of this study did not allow for both cassava and yam to be included. A joint decision with RVO and EKN was made to analyse the following five agricultural value chains for this study: cashew, cassava, cocoa, palm oil and natural rubber.

Table 1 Quantification of the main agricultural residues in Côte d'Ivoire (source: GIZ, 2020)

Value chain	Agricultural residue	Estimated quantities
Cocoa	Bean shells	4,36 million tons dry weight
	Pod husks	43.760 tonnes
	Tree residues	400.000 ha with plants more than 30 years old
Cashew	Shells	49.000 tonnes
	Apples	5.000.000 tonnes
Oil palm	Empty Fruit Bunches	1.542.000 tonnes
	Ageing oil palms	*Evaluation to be conducted*
Rubber tree	Ageing rubber trees	500.000 m^3 for timber, 600.000 m^3 for energy
	Rubber seeds	65.000 tonnes

Approach for assessing the quantity of agricultural biomass by region

The analysis of material flows for these five value chains focuses on: (i) quantifying the biomass produced by agricultural sector and by region and (ii) assessing the energy potential of biomass by region. As a first step, a dataset was set up for each of the administrative regions to present the potential of agricultural biomass and the energy potential represented by this biomass. The database was set up by integrating data from government structures in charge of agriculture (ANADER, FIRCA), national research institutes (BNETD, IGN), international organisations and NGOs (IED, GIZ etc.) and local experts. All the actors involved, and their respective roles are specified in the section on stakeholder mapping. The analysis of biomass potential is based on an iterative calculation process using statistical data, study reports and interviews with experts and key players in the various agricultural value chains.

A typology of waste by type of agricultural sector was carried out and can be found in Annex G. The estimate of agricultural production on the basis of the areas planted for all the agricultural value chains under consideration is determined by region. The values of these areas are provided by the report "Technical studies of biomass power plants" carried out in 2020 on the basis of data from the last census of agricultural surfaces in 2016 by Innovation Energie Développement (IED) in collaboration with ELCIMA. In addition, direct contacts were initiated with relevant stakeholders including the councils responsible for the crops under study: Conseil de Café-Cacao, Conseil de Coton-Anacarde, Conseil de Hévéa-Palmier à Huile. This has resulted in more recent and more accurate production data per region. Biomass potentials are presented according to their quantity and energy potential.

To complement field and literature research, seven Dutch companies and one Dutch university were contacted to gather their vision, expertise, and potential technological match for the valorisation of agricultural residue streams in Côte d'Ivoire. As a key partner of RVO and an instrumental financing institution in the development finance sphere, FMO, the Dutch development bank, was also interviewed. The list of interviewees is available in the bibliography [vv] and in the separately presented stakeholder map(E).

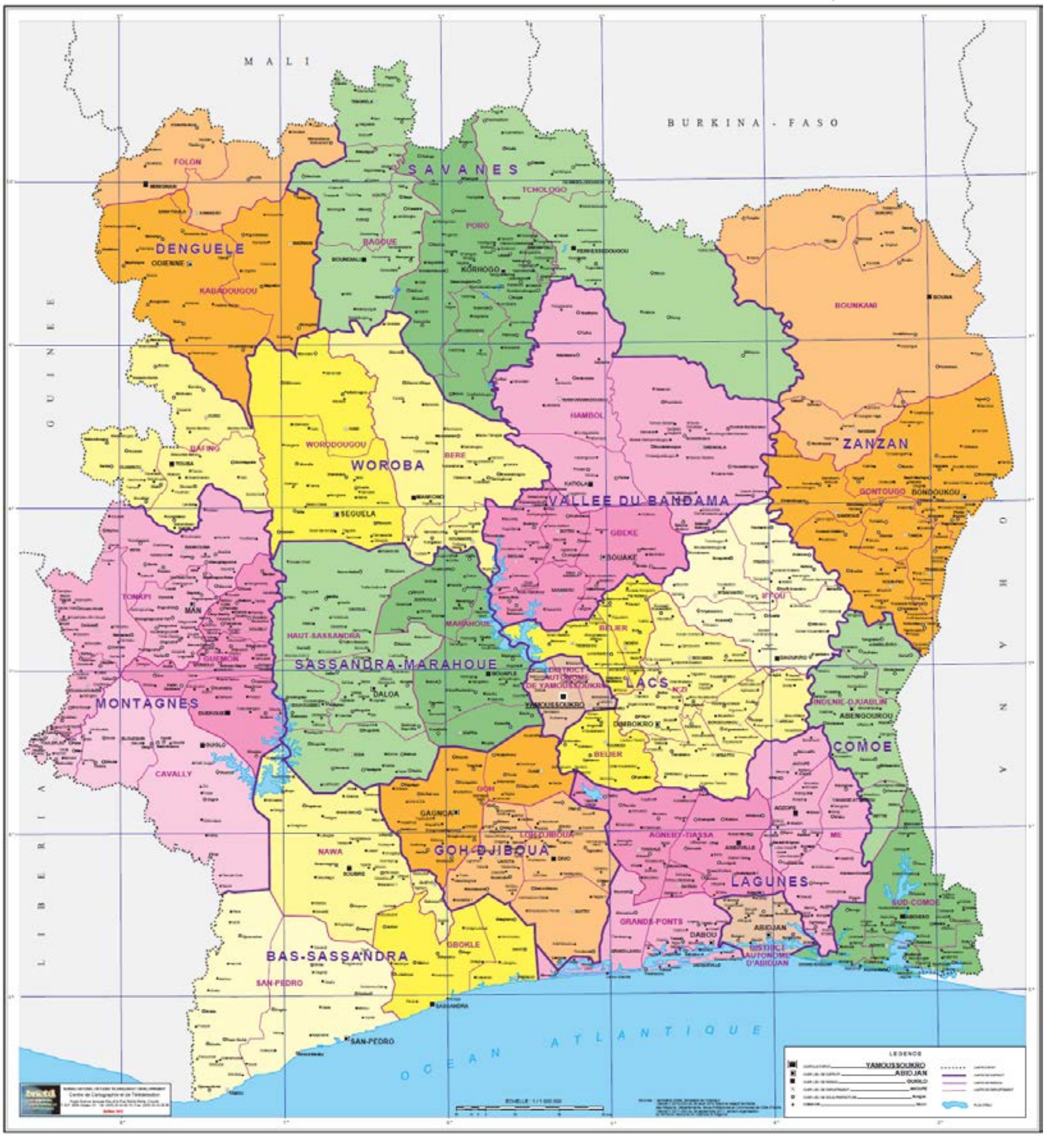

Figure 3 Districts, regions and departments of Côte d'Ivoire (source: website national government)

2.3 Methodology to identify, assess and select the valorisation routes

Identification of valorisation routes

Throughout the identification of cases, several key points served as navigation:

1. Potential competition with alternative applications
2. Environmental impact
3. Circularity
4. Strengthening the local sector
5. Economic impact

Annex B. details the full inventory of each identified application.

As indicated in paragraph 1.4, this study commenced with a detailed assessment of available residues in the selected agricultural value chains (Annex G) and an inventory of potential energy applications for these residues, including energy demand within the respective agricultural value chain. Energy applications within the value chain were prioritised due to potential positive impact on logistics

(transport, storage costs), the ToR objective to benefit the local sector, and circularity of the value chain.
The potential amounts of available residues were calculated based on national and regional production figures and conversion factors for the volume of agricultural residues per tonne of product. This calculation was complemented with an assessment of the actual availability of the respective residue. Existing applications of residues were considered to avoid any potential competition with feed or food.

High level sustainability inventory

The use of biomass has been subject of public discourse due to potential links with environmental risks. Additionally, several value chains included in this study have been linked to environmental and/ or social issues such as deforestation, labour misconduct, and community displacement. Any potential follow-up activity resulting from this study needs to be vetted thoroughly to make sure it contributes to mitigation of such issues. The scope of the current study allowed for a qualitative high-level multi-criteria inventory to identify potential negative and positive sustainability aspects of each proposed use case. Based on this identification, some productive use cases with potential (serious) negative impacts were dismissed, and the most promising cases in terms of sustainability were selected. Annex B provides an overview of the inventory. The following paragraphs provide a brief description of the criteria that were applied.

Social sustainability aspects

Employment and business opportunities, including for vulnerable target groups

Results of this study should strengthen the local sectors. Potential creation of business opportunities and employment therefore contributed to positive evaluation. In addition, business, and employment opportunities for vulnerable groups such as youth and female entrepreneurs were prioritised. This is in line with the Netherlands international cooperation policies (building further upon the scoping mission that was conducted by the Ministry of Foreign Affairs in 2020[3] [q].

Working conditions

Any potential negative impact on working conditions should be avoided or mitigated. In most productive use cases that were assessed no potential impacts on working conditions were flagged (i.e. no significant changes are foreseen through implementation of biomass applications, it is to be noted that assessing current working conditions in the respective sectors is outside the scope of this study). However, substitution of fuels can for instance have an impact on working conditions as well as on local air quality (see also below under environmental aspects), and specific operations may require mitigation measures such as protective clothing.

Environmental aspects

Climate impact

Biomass is considered to be a source of renewable energy due to the regenerative nature of short-cycle organic material (e.g. the CO_2 emitted by using wood fuel is stored in new trees during their growth) as opposed to fossil fuels, which are finite and contribute to additional greenhouse gas emissions. This does however require sustainable management of renewable resources. In addition, renewable is not synonymous with climate neutral, since the processing, transport and conversion of biomass can lead to negative climatic impacts that may reduce or even completely offset the positive impact. Starting point for the study is that the use of agricultural residues should have a net

[3] https://www.rvo.nl/sites/default/files/2021/03/Scoping-Mission-Catalyzing-Womens-Entrepreneurship-in-Cote-dIvoire.pdf

positive climate impact. Any negative climate impact (e.g. through transport of biomass) should be avoided where possible.

Local air quality

Utilising biomass as a substitute for currently used fuel types may have positive or negative impacts on local air quality. For instance, the use of biogas for cooking instead of fuel wood has a positive impact on local air quality (through reduction of particulate matter, PAH) as well as on preventing deforestation (see following paragraph), while the direct combustion of cashew shells instead of fuel wood leads to a negative air quality impact as the presence of cashew nut shell liquid (CNSL) leads to toxic fumes.

Land-use and deforestation

Deforestation is a major problem in Côte d'Ivoire. The use of charcoal for cooking is the second most important cause of deforestation. On a global level, agriculture as well as the use of bio-energy has been linked to deforestation and land-use-change (LUC). Deforestation and LUC are key causes of CO_2 emissions. Any negative impact on land-use should therefore be avoided, including loss of soil fertility by removal of organic matter. Negative impacts on land-use can either be direct, e.g. through unsustainable use of fuel wood or indirect, e.g. logging with the purpose to grow energy crops.

Cascading use of biomass and circular economy

An important starting point for the utilisation of biomass that has been developed over the last two decades is the principle of cascading use, i.e. that biomass resources should as much as possible be used in the application with the highest added value (see Figure 4). In addition, the principle of circularity is gaining momentum, which implies maintaining products and materials in continuous use cycles. This principle entails ensuring that productive use is prolonged (e.g. by optimising maintenance and refurbishment) and at the end of life products, components and materials are recovered and prepared for a new use cycle.

A simple example of cascading use of biomass is the use of wood in a material application, e.g. a table (level 4 in the pyramid) that is at its end-of-life used as input material for fuel pellets (level 3) or to generate heat directly (level 2), after which the ashes may be used to improve soils (level 1). Cascading can hence be seen in time, but also be specific for each by-product (e.g. the saw-dust from wood production can be applied to produce pellets, while the timber is used in a high quality material application). In addition, it is to be noted that development of the value chain for a lower value level may be necessary to produce materials and products at a higher level at a later stage.

The principle of the circular economy in addition implies ensuring that products and materials are maintained and reused at the highest level (in the example of the table, ensuring its life span is extended through maintenance and repair, and at the end-of-life reusing the materials to create new furniture to the extent possible).

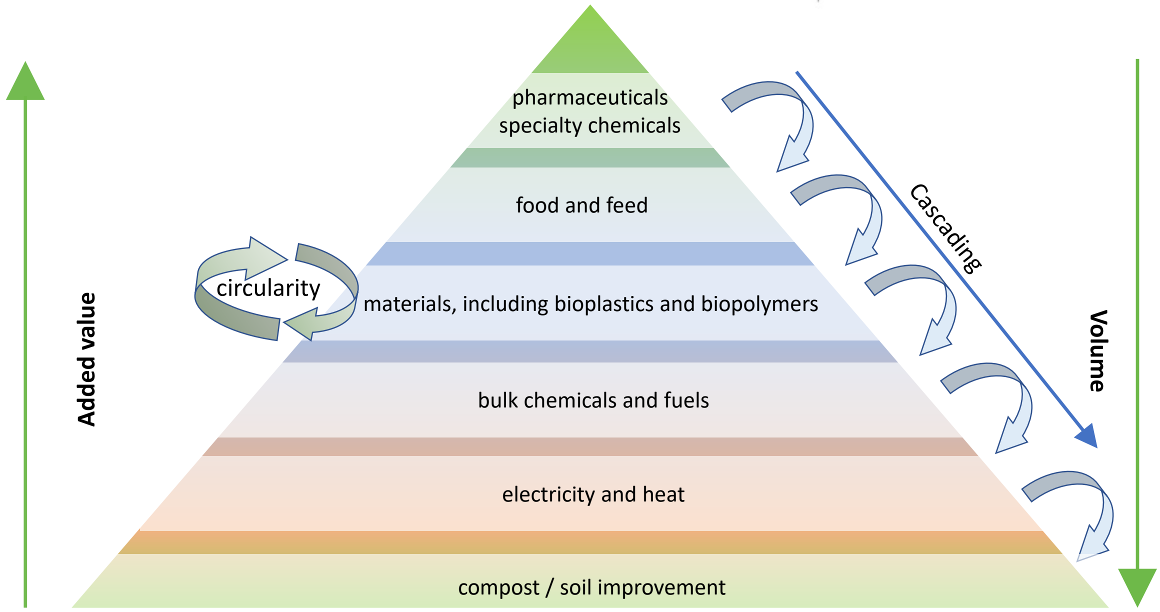

Figure 4 Cascading use of biomass resources (PfI, based inter alia on Ministry of LNV, 2007)

The agricultural residues covered in this study cover the full range of the pyramid (both in their current use and in their potential future application). The cardanol that can be produced by upgrading CNSL can for instance be applied in high value specialty applications, many agricultural residues can be used to produce food or feed, several residues have a potential for use as input material for bioplastics. A particular point of attention with regard to the compost/soil improvement level, which is at the bottom of the pyramid in terms of added value, is that soil fertility is a pre-condition for all agricultural value chains addressed: erosion and loss of nutrients should hence be avoided at all times. In the assessment this is also covered under 'land-use' in which risks of erosion and/or loss of soil fertility are highlighted.

Economic aspects

Cost reduction

The productive use of agricultural residues may lead to cost reductions, for instance by reducing waste management costs and/or reducing fuel costs. Potential cost reduction was identified as a positive factor in the qualitative impact assessment.

Profitability

Profitability served as a criterion to assess market potential of a residue or residue-based product. Elements considered include market prices, costs associated with the recovery/collection of the residue stream, and further production costs.

CAPEX / investment required

Indication of instances in which high upfront investment costs (e.g. in equipment or infrastructure) are likely to be required for the productive use case, which would have an impact on financing requirements and likely also on resources and capacities required for valorisation of the respective agricultural residue.

3. Cashew value chain

3.1 Short outline of the sector in Ivory Coast

Production volume and characteristics of the sector

Côte d'Ivoire is one of the world's leading producers and exporters of raw cashew nuts (RCN). Production has fluctuated somewhat in the past decade but has in recent years increased considerably – from 634.631 tonnes of RCN in 2019 to 848.700 tonnes of RCN in 2020 (Conseil du Coton et Anacarde, 2021), an increase of 34%. However, the country processes only a limited amount of its national production locally (estimated at 100.000 Mt in 2020, and 68.000 in 2018 [GIZ, 2018]). The Ivorian government has however set ambitious targets to increase the tonnage of product processed domestically and thereby increase the added value of cashew production. Programmes were set up to facilitate this increase, including a large World Bank financed project entailing $ 285 million USD targeted inter alia at increasing processing capacity and improving logistics and storage capacity (CBI, 2018).

Structure of the sector

The sector consists of predominantly farmers (330.000) and a limited number of processors (35). The following table provides an overview of the largest domestic processors.

Table 2 Overview of industrial cashew processing units in Côte d'Ivoire (source: Conseil du Coton et de l'Anarcade, 2021)

N°	Name	Place	Installed capacity (t/yr)
1	Afrique Agri Industries	Goumere	70.000
2	OLAM 1	Bouake	30.000
3	Cilagri Cajou	Abidjan	30.000
4	GIE/GEPPA	Yamoussoukro	30.000
5	OLAM 3	Anyama	15.000
6	NOVAREA	Yamoussoukro	15.000
7	Ivory Cashew Nut (ICN)	Bouaké	15.000
8	Huxley Global	Zuenoula	15.000
9	Dorado Ivory	Toumodi	15.000
10	OLAM 2	Dimbokro	12.000
11	Ivoirienne de Noix de Cajou (INC)	Azaguié	12.000
12	FMA Industry	Korhogo	10.000
13	Société Ivoirienne de Traitement de l'Anacarde (SITA)	Odienne	10.000
14	Quan Thien Imex	Abidjan, ZI Yopougon	10.000
15	Denia Ivoire SA	VITIB/Grand Bassam	10.000
16	Nord Cajou	Seguela	6.000
17	Société de Treansformation de Noix de Cajou (STNC)	Yopougon	6.000
18	Foods Co S.A	Béoumi	6.000
19	Centre d'Innovations et de Technologies de l'Anacarde (CITA)	Yamoussoukro Technopole	6.000
20	Côte d'Ivoire Cajou	Dabakala	6.000
21	Cajou des Savanes	Bouake	5.000
22	SOBERY	Bouake	5.000
23	Africa Negoce	Bouake	5.000
24	Agirculture Ivoirienne AISA	Toumodi	5.000

25	Global Cashew	Odienné	3.500
26	KIYO	Zuenoula	3.000
27	AGRO FRONAN	Fronan	3.000
28	CAJU INDUSTRIE	Kolia	3.000
29	BOHAIMAN Group	Abidjan	3.000
30	Transua Cajou	Transua	2.500
31	AFRICAJOU	Bondoukou	2.000
32	Cajou de Fassou	Yamoussoukro	1.300
33	COOPABO	Bondoukou	1.000
34	Benie Cajou Ivoire	Bouake BEAUFORT	1.000
35	SCOOPCA COPRODIGO	Zuenoula	360
	Total		**372.660**

In addition, ten cashew processing plants are currently under development, representing an additional installed capacity of almost 250.000 tonnes [nn].

The installed processing capacity has already considerably increased in recent years. In 2015, production was still at a relatively modest level (at 56.000 tonnes). By 2017 this number had doubled [c]. This rapid expansion rate is expected to continue. A tenfold of the 2015 level is expected to be reached in the coming years. This growth will coincide with a steep increase of cashew nut shell availability in Côte d'Ivoire. Currently, cashew nut shells largely occur in processing countries, such as India, Vietnam and Brazil.

Main regional differences

Cashew production takes place throughout a large part of the country and is most prominent in the regions of Béré, Gbeke and Hambol. The following figure shows, based on the regional production figures, the amounts of residues of the cashew value chain per region.

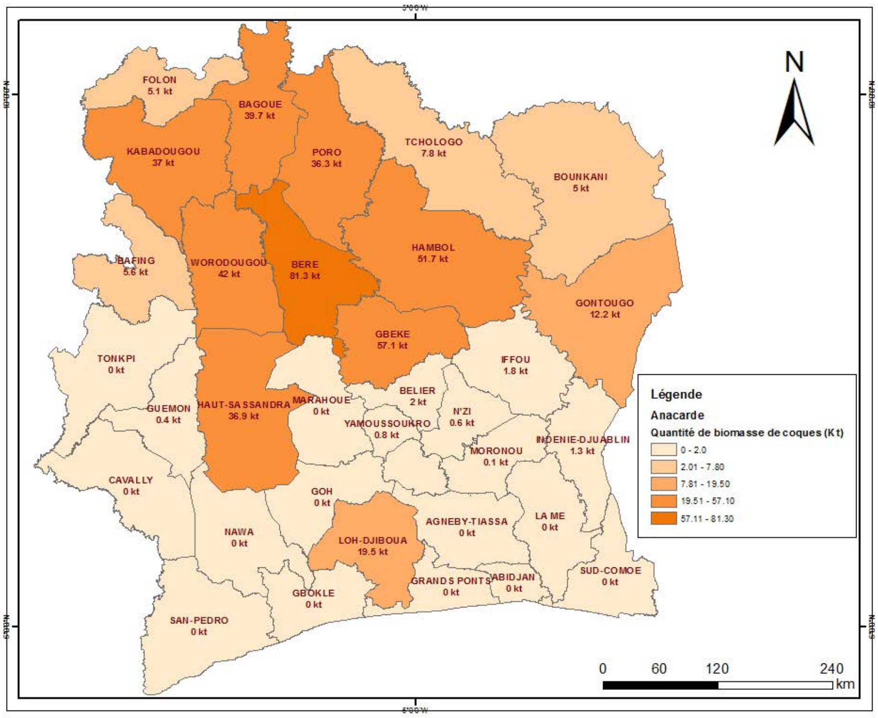

Figure 5 Quantities of cashew by-products produced per region: cashew shells

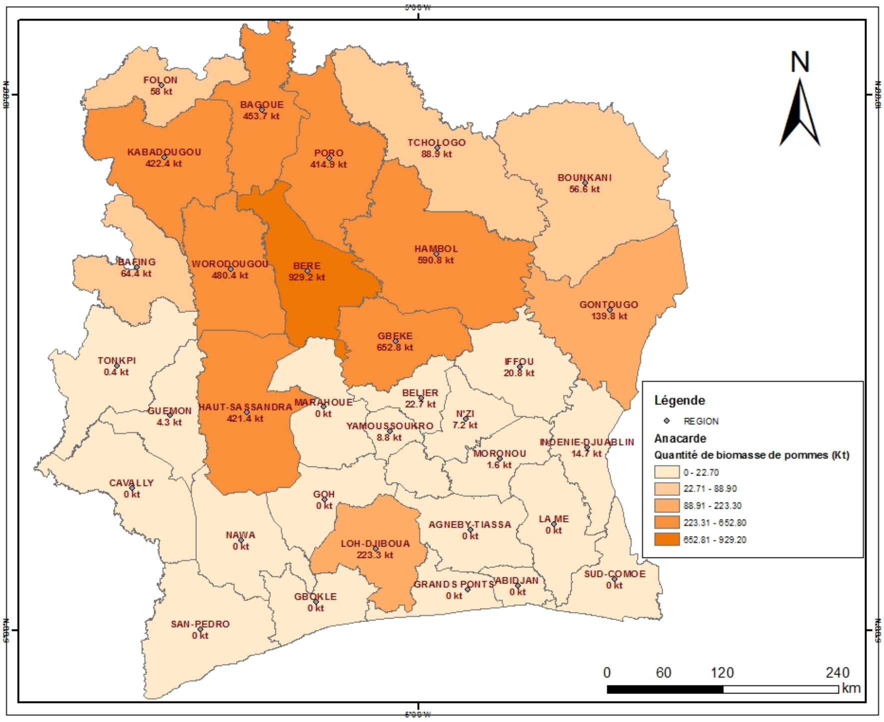

Figure 6 Quantities of cashew by-products produced per region: cashew apples

Ongoing initiatives

Several initiatives have been launched in Côte d'Ivoire to stimulate a more circular and sustainable cashew value chain, including utilisation of cashew by-products. The following initiatives are most relevant to the current study:

- CBI projects on the cashew value chain: the Centre for the Promotion of Imports from developing countries (CBI) of the Netherlands Ministry of Foreign Affairs has been active in the cashew value for several years and is currently implementing its 'Cashew Côte d'Ivoire' programme (2020-2024)[4]. As part of the programme, currently a study is conducted into feasibility of local sales of CNSL.
- GIZ cashew value chain projects: various relevant studies have been conducted by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), including the aforementioned 'Partnership Ready Côte d'Ivoire'. The recently finalised Competitive Cashew Initiative (ComCashew)[5] was conducted between 2009 and 2020 in six African countries including Côte d'Ivoire' with the aim to increase the competitiveness of the cashew value chain in these countries, including through the productive use of by-products.
- ELECTRICI – Recycling of cashew waste in the OLAM plant to produce electricity[6]: project in which OLAM, Nitidae, AFD, Chigata and Urja Nishati are cooperating to utilise cashew nut shells for the production of energy through pyrolysis ("High Calorific Cashew Pyrolyser (H2CP)").

3.2 Overview of production process steps, by-products and energy use

The following figure provides a schematic overview of the main cashew processing steps and resulting by-products. These by-products are described in more detail in the subsequent paragraphs.

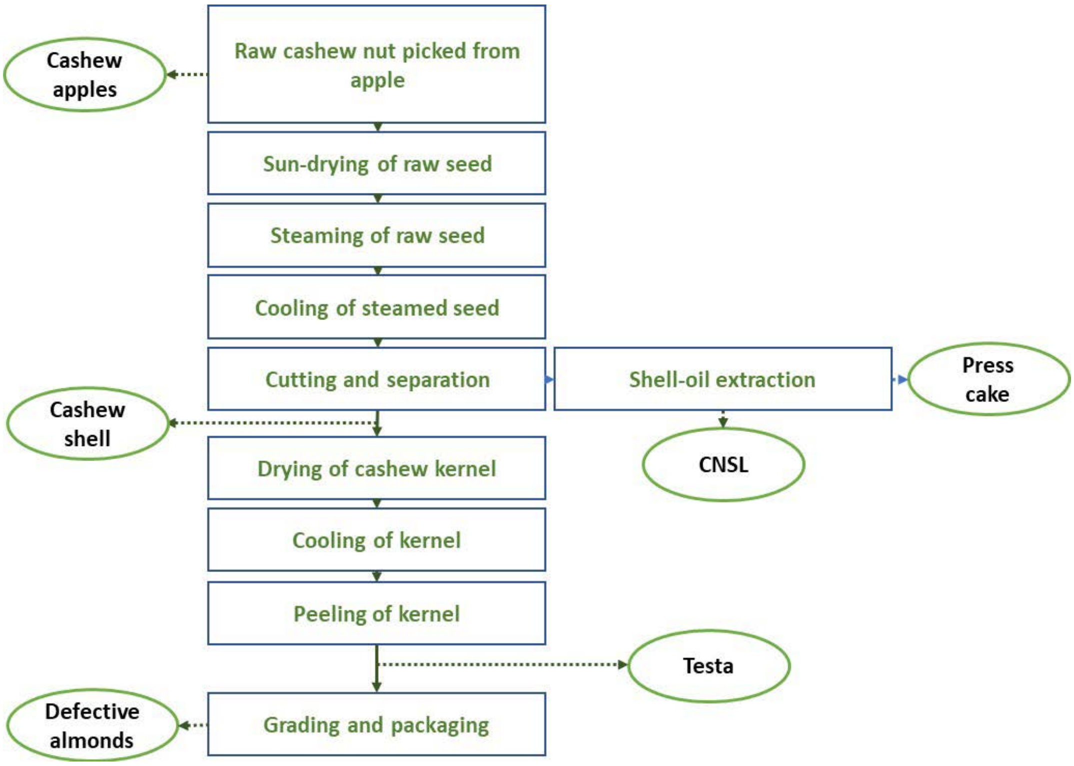

Figure 7 Flow chart of cashew nut processing in small processing plants (based on IED, 2020)

[4] https://www.cbi.eu/projects/cashew-cote-d%E2%80%99ivoire
[5] https://www.giz.de/en/worldwide/19011.html
[6] https://www.nitidae.org/en/actions/electrici-valorisation-energetique-des-dechets-de-l-anacarde-usine-olam-de-bouake-pour-produire-et-distribuer-de-l-electricite

Potential energy use within the cashew processing value chain

The following table provides the energy demand corresponding to the two most energy intensive processing steps: steaming, and cutting and separation.

Table 3 Energy demand for cashew processing (for 1.000 kg RCN) [r]

Process step	Thermal (MJ)	Electrical (MJ)	Manual (MJ)
Steaming of raw seed	2.969,7	431,8	17,2
Cutting and separation			112,9
Total	2.969,7	431,8	130,1

By-products of cashew production

Cashew apples

The cashew apple is the peduncle of the fruit of the cashew tree to which the raw nut is attached. In terms of volume and mass, it is by far the largest part of the fruit. The cashew apple accounts for about 80% of the weight of the whole fruit.

Cashew apples can be valorised to produce alcoholic and non-alcoholic beverages, surfactants, enzymes, lactic acid, probiotics and complex sugars (oligosaccharides)[y]. Currently, there are examples of small-scale projects in Côte d'Ivoire that produce beverages. Moreover, cashew apples can be utilised to produce energy through several technologies. These technologies include anaerobic digestion or production of bioethanol, for instance through the fermentation and subsequent distillation of cashew apple juice [g]. The vast majority (99% [c])of the cashew apples is left in the field after removal of the raw nut, which leads to considerable greenhouse gas emissions (see also below under 3.3).

Cashew nut shells / CNSL and press cake

The cashew nut shell is the protective structure surrounding the almond. Once broken, it releases Cashew Nut Shell Liquid (CNSL) and the almond from the cashew nut. By mechanical extraction and decarboxylation of the raw shell, the following by-products are obtained:

- T-CNSL (Technical Cashew Nut Shell Liquid, which is CNSL after decarboxylation: 22%): CNSL is a brown viscous substance found between the two outer layers of the cashew shell. In its pure form, the liquid is caustic and toxic, and can hence create health issues for workers in the deshelling step. CNSL can be distilled to cardanol, which can be applied in various industrial applications as a lubrication or insulation material, or as a resource material for the production of resins, paints and coatings. The most prominent use is however the application as a fuel, either directly (in pure form or in a mixture with other fuel, mainly DDO) or after upgrading to biodiesel.
- Press cake (73%): the de-oiled shell cake can be applied as fuel replacing firewood, either directly or in briquetted form.
- sludge residue (± 5%).

In some cases, cashew shells have been applied as a fuel source through direct combustion. However, CNSL creates toxic fumes in the incineration process, which leads to air pollution and related health issues. The raw shell can however be upgraded by a pyrolysis process to produce biochar briquettes and to fuel boilers.

Testa
The husk surrounding the almond is a reddish-brown integument (called 'testa'), which is rich in condensed tannins. The main application for the testa (if any) is use as feed for poultry.

Defective almonds
Defective almonds are the damaged nuts that are discarded in the last part of the process, grading and packaging. These are usually applied as livestock feed but can also be used to produce food ingredients (cashew paste or cashew oil).

Energy potential of by-products of cashew production
For the main energy applications as outlined above, the energy potential expressed in MJ/kg (Lower Heating Value or LHV, i.e. the amount of energy released by combustion of a specified amount of a substance) is provided in the following table.

Table 4 Lower Heating Value of various cashew processing by-products (ACA, 2018[dd] based on various sources)

By-product	LHV (MJ/kg)
Cashew shells	18,9
CNSL	36,1
Shell cake	17,4
Shell charcoal	29,9

The calorific value of the (de-oiled) shells is comparable to dry, resin-free fuel wood. The de-oiled shells, the shell cake (either directly or after briquetting) and shell charcoal can be applied to substitute fuel wood in a variety of applications, ranging from direct application in cookstoves or as a fuel to power boilers (for instance in the steaming and drying steps of the cashew process).

The overall theoretical energy potential per region as calculated on basis of the production figures is provided in Annex A. Total theoretical availability of cashew nut shells in the year 2019 is estimated at 444.000 Mt (based on a weight percentage of the shell being 67.5% of raw nut[r]), total quantity of cashew apples is estimated at 5.077.100 Mt. The overall theoretical potential at the national level is estimated on this basis at around 1.900 GWh for the cashew nut shells and 7.400 GWh for cashew apples The regions of Béré, Gbeke and Hambol are the areas with the highest energy potential.

However, it should be stressed that this is the *theoretical* potential: since the share of RCN processed within the country was recently at max. 44% (based on 2020 figures, i.e. national processing of 372.660 Mt of the total production of 850.000 Mt RCN), at least 66% of the shells are currently exported (and in most cases valorised in the countries in which they are processed).
With regard to the cashew apples, as mentioned only 1% is currently collected and valorised, mainly due to practical limitations – the apples are fragile and should be processed quickly with minimal transport, which poses a considerable logistic challenge.

3.3 Valorisation potential of by-products and related sustainability aspects

As outlined in chapter 2, sustainability considerations include applying available biomass in the highest possible value application, where possible through cascading use in which the material is first used in the highest possible value application and are only (directly) applied as energy source when higher value applications are not available. Since the testa and defected almonds can be applied directly in food/feed applications, for the cashew value chain the study focuses on the energy valorisation potential of the shells and cashew apples. For the latter it should be noted that these can also be applied for food production, however this can be combined with energy production: production of cashew juice yields a pulp residue that can be applied as an energy resource through anaerobic digestion. Main obstacle to overcome however is that currently only 1% is utilised, while the remaining 99% is left in the field, leading to considerable emissions of methane and CO_2.

The following paragraphs provides a high-level summary of sustainability aspects related to the application of cashew shells and apples, further details can be found in Annex 0.

Cashew shells / CNSL

Environmental aspects: emissions, climate impact, cascade and land-use

The processing of shells to fuel applications can be by direct combustion, through production of biochar or through production of T-CNSL. The latter is the preferable application from an environmental and economic perspective, as the energy efficiency is considerably higher than both other options. Direct combustion is the least preferred due to the high risk of harmful emissions, which is also a point of attention for the biochar production process.
Overall climate impact is positive as the cashew shell based fuel substitutes fossil fuel or fuel wood, in the latter case contributing as well to combating deforestation/erosion. In addition, methane and CO_2 are releasing when the shells are dumped and decompose, which leads to calculated emissions of 0.10 tCO_2eq/Mt [dd].

Developing the CNSL-option opens up the longer-term perspective of upgrading to cardanol, which can be applied as a resource material for a variety of chemical products which creates a significantly higher value (US$ 700-800/Mt) than the CNSL fuel price, which is currently at around US$ 300/Mt [ww]. This however requires the investment in a distillation unit and is currently not yet applied in West-Africa due to the required scale of operation (> 10.000 Mt/yr) [dd].

Socio-economic aspects/working conditions

Opportunities for the creation of new business opportunities are expected to evolve in the logistics and processing of the shells. As a result of the caustic nature of the liquid, working conditions (including providing protective clothing/gloves where necessary) are an important point of attention in the deshelling process step and further processing of the CNSL.

Cashew apples

Environmental aspects: emissions, climate impact, cascade and land-use

The current standard practice of leaving the cashew apples in the field leads – in view of the quantities concerned (an estimated 5.077.100 Mt in 2019) to huge amounts of methane being released as a result of the decomposition process. Applying the cascade principle would favour the food / beverage application while residues of these production processes (such as the pulp residue from juice making) can be applied for energy purposes.

Socio-economic aspects/working conditions

Setting up the cashew apple juice/biogas value chain could lead to business opportunities and job creation, as well as in creating a healthy addition to local diets (the apples are very rich in vitamin C: 4-7 times more than in orange juice and contain branched-chain amino acids and anacardic acids which have beneficial health impacts) [z].

Main challenge to be overcome is the dispersed availability of this by-product in combination with the limited possibilities of collection: cashew fruits are picked from the ground rather than plucked because it is hard to assess when they are ripe – most fruits are damaged when they fall from the tree and start to ferment within hours.

3.4 Productive use cases and related business opportunities

Cashew shells / CNSL

The production of CNSL has previously been conducted by two of the larger cashew processors in CDI, OLAM and Sita, however they decided to stop due to the low CNSL price [dd]. Direct application of CNSL as a fuel, either as a single fuel or in a mixture with DDO could however be profitable through avoided fossil fuel costs and costs of discarding the shells. With regard to this valorisation option, a feasibility study is currently ongoing under coordination of the Netherlands Centre for the Promotion of Imports from developing countries (CBI), of which the first phase is conducted by Funteni and Nitidae [gg]. This valorisation option is likely to be pursued further through direct use of the CNSL as fuel in a sugar processing plant and/or in a mixture with DDO at small enterprises such as bakeries and foundries. The latter option is however more complex in view of the mixing step that would need to be part of the process [ww].

The first phase report mentions that there are local market opportunities for the press cake but does not yet provide further detail regarding the valorisation of this main by-product of CNSL production which represents 73% of the total weight of the shells. Valorisation of the press cake, including for instance the potential in terms of jobs and business opportunities in briquetting could be explored in the following phase.

Cashew apples

For the productive use case for cashew apples, further research is deemed to be necessary targeted mainly at an increased share of apples available as resource material, which would imply a decrease of damaged / fermenting apples. Experience in Brazil shows that processing of 12% of the apples is possible [a], showing high potential from the current 1% in Côte d'Ivoire (of which 0,9% is consumed directly and only 0,1% is processed into juice [c]). The variety of the cashew tree has an impact on this element, in addition reduction of damage could be achieved by adapting the harvesting method at the plantations. Since this would bring about additional effort and investment, the market opportunity posed by cashew apple processing should be further explored.

The efforts of the Ivorian government to promote an increase of local processing of RCN could be a stimulating factor. This may entail both an increase of capacity at existing processors (see Table 2) and an opportunity for new processors entering the market – regarding the latter, efforts could be increased to create processing capacity at larger cashew farmers or cooperatives of cashew farmers. In this case, the valorisation of the cashew apples could become part of the overall investment in processing capacity and contribute to the turnover and profitability of the enterprise. In addition to adding value to the cashew nut value chain, this add-on to the existing efforts of increasing domestic processing capacity would bring about opportunities for new businesses in the value chain for cashew apple products, including food, beverages and utilisation of residues for energy production.

4. Cassava value chain

4.1 Short outline of the sector in Ivory Coast

Production volume and characteristics of the sector

Overall production volume of cassava in the country has increased steeply in the last decade and is currently at 5.877.230 tonnes (BNETD 2020, figure for 2019). As the peelings represent on average approximately 10% of the fresh cassava, this represents a total of 588.000 tonnes of cassava residues.

Structure of the sector

The sector represents an employment to approximately 425.000 (full time equivalent) jobs most of which are in small-scale retail, agriculture and artisanal production of cassava products (mainly Attiéké), while only approximately 5% is active in (semi-)industrial production [d].

Main regional differences

The Sud-Comoé region is by far the largest producer of cassava, and hence also has the largest availability of cassava peelings.

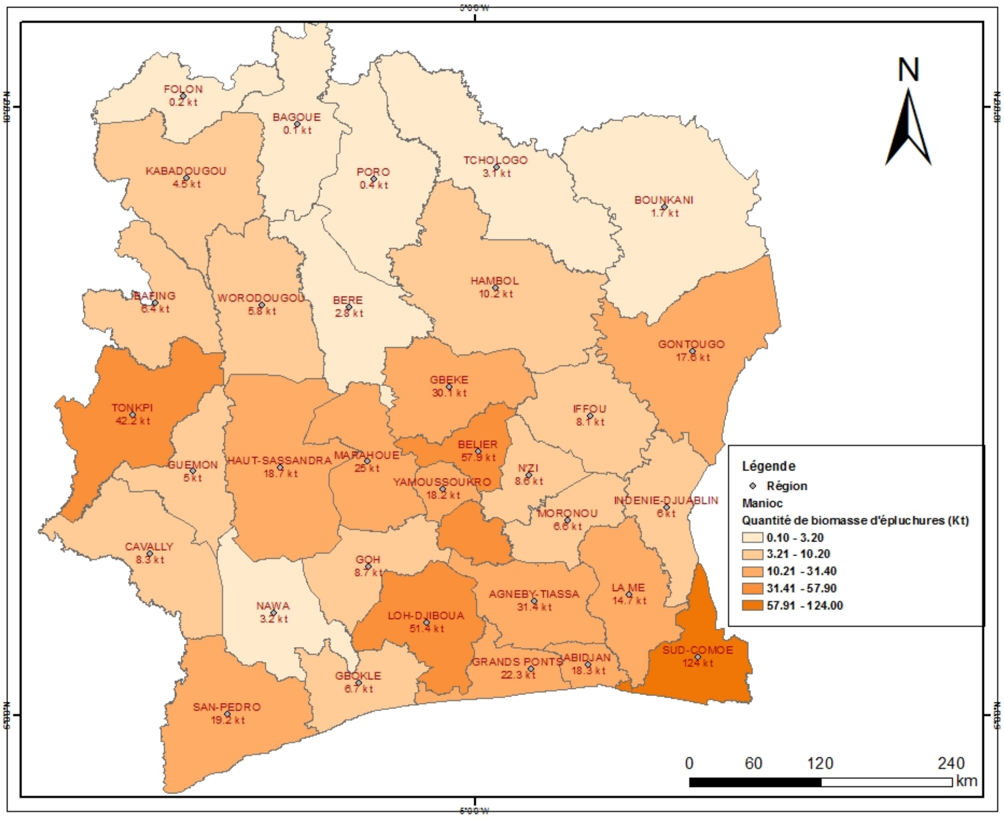

Figure 8 Volume of cassava peelings per region

Ongoing initiatives

The Ministry of Environment and Sustainable Development of Côte d'Ivoire has in recently (September 2020) launched a project entitled "*La production industrielle durable de manioc et d'autres secteurs agro-alimentaires grâce à l'utilisation d'énergies renouvelables et de technologies à faibles émissions de carbone*"[7]. The project is partly financed by the GEF, has a budget of 385 million

[7] http://environnement.gouv.ci/actualite.php?rd=831

FCFA and will be coordinated by UNIDO. Main aim is to reduce greenhouse gas emissions. In the implementation phase, cassava residues and other agricultural waste streams that are currently burned in the field will be valorised through the use of innovative technologies for the production of renewable energy.
Ivorian company LONO is installing a digestor to convert the waste from the transformation process, into compost and cooking gas. This project is funded by Nitidae and the regional administration of Mé. The company Edindia SA is developing the production of bioethanol from cassava peelings, through a process of fermentation and subsequent distillation.

4.2 Overview of production process steps and related energy use

Figure: process overview, residues

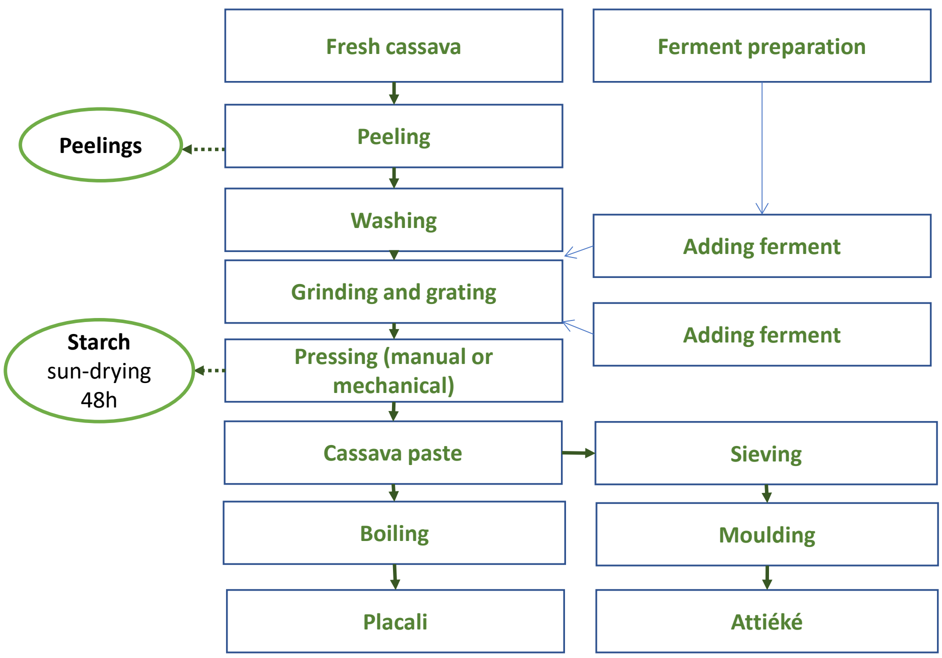

Figure 9 Overview of production process of Placali and Attiéké

Potential energy use within the cassava processing value chain

In view of the predominantly artisanal nature of production these process steps are to a large extent conducted manually, main thermal energy use is related to the boiling step in which fuelwood is the dominant source of energy. Processing units are generally traditional and have rudimentary equipment. In (semi-) industrial processing the grinding and grating step is generally mechanised, powered by electricity or diesel. When converted to biogas, cassava residues could form an energy source for the cooking step in small-scale production. At large scale, biogas (where possible in view of the energy demand in combination with electricity generation) could provide an energy source also for the mechanised production steps and drying of the starch.

By-products of cassava production

Peelings

The peelings represent between 5 and 15% of the total weight of the cassava root. In the current study the estimates are based on an average 10%. The peelings currently mainly find their way to livestock feed applications.

Starch

The cassava starch is a by-product (utilised as a food ingredient) in traditional cassava processing, and may either be a by-product or the main product in industrial processing. In either application the cassava starch forms an important food product and is hence not available for energy applications.

Sludge

In the case of (semi-)industrial production the process also has sludge as a by-product. This can amount to approximately 1 m^3 per tonne of product, which leads to a considerable problematic waste stream with a large volume and strong odour [zz]. Costs of removal/treatment of the sludge are in the range of 20-30% of overall turnover, making it also a costly waste stream.

Table 5 LHV of cassava peelings

By-product	LHV (MJ/kg)
Peelings	10,6 [s]

4.3 Valorisation potential of by-products and related sustainability aspects

Peelings

Environmental aspects: emissions, climate impact, cascade and land-use

In general, the cassava value chain has only limited environmental impacts due to its extensive production method with few inputs and alternating production method (normally three years production after which the land is left fallow to enable restoring soil fertility)[d].

As mentioned, the main application of the peelings is currently livestock feed. Any new application should therefore carefully consider whether competition with feed might occur. In cases where no direct application is available for the peelings, small-scale biogas production could be a viable option, in which the biogas could directly be applied in the boiling step – replacing fuelwood, reducing negative impacts (human health, deforestation).

Socio-economic impacts and working conditions

As in many agricultural sectors (see also previous chapter), in particular in more traditional oriented crops, children are helping in the production. It is not always easy to determine whether this should be regarded as child labour as in many cases agriculture is conducted by small-scale producers – their family helps out in busy periods. A large majority of children in Côte d'Ivoire attends primary school, in many cases helping out their parents after school [ee].

The cassava sector shows a strong representation of women in all process steps, including in decision-making positions. Most of the cassava traders are female [e]. A point of attention however is that access to capital for this group remains low as compared to male market actors [d].

Sludge

Environmental aspects: emissions, climate impact, cascade and land-use

Anaerobic digestion could also be applied for the sludge that occurs in industrial processing. It is however to be noted that further research should be performed with regard to application possibilities of the fermentation residue, for instance as a fertilizer. In this case the biogas would replace fossil fuel used in the drying step and potentially mechanical processing steps.

Socio-economic impacts and working conditions

Same as above, whereas obviously capital investment increases with the scale of operations. The position of women is due to lacking access to capital less powerful in this type of production, making this point for amelioration more prominent.

4.4 Productive use cases and related business opportunities

Small-scale digesters represent a proven technology, however effectiveness and energy yield largely depends on the feedstock used. In many cases a mixture of organic residues is used to optimise the digestion process and hence the energy balance. Business opportunities can as a result arise from the development, construction, operation (including collecting and mixing of feedstock where applicable) and maintenance of biodigesters.

In a case study in Nigeria, based on a typical cassava starch processing plant with a production of 25 tonnes/day, using diesel as a main fuel to heat the boilers and electricity for the grinding step, it was calculated that annual cost savings of approximately 160 k€ are feasible mainly as a result of avoided fuel and electricity costs. In that particular case this led to a payback period of approximately 3-4 years[8].

However, developing the business case for larger scale biogas applications requires a thorough case specific feasibility study – for the case of cassava processing factories viability of biogas production from sludge and peelings would largely depend on the balance between electric and thermal energy demand, as well as on the current costs associated with waste processing.

[8] https://partnersforinnovation.com/wp-content/uploads/2019/04/Marktstudie-captive-power-Nigeria.pdf

5. Cocoa

5.1 Short outline of the cocoa sector in Ivory Coast

Production volume and characteristics of the sector

Côte d'Ivoire is the largest cocoa producing country in the world, providing around 36% of global cocoa bean supply [n]. Côte d'Ivoire is also the largest exporter of cocoa beans, holding a market share of 29%, which corresponds to an export value of 2 to 3 billion euros [k]. Annual production of dry cocoa beans in Côte d'Ivoire was estimated at 2.105 kMt in 2019/2020 by the International Cocoa Organization (ICCO) [o].

Structure of the sector

Like palm oil and cassava, cocoa is grown in two main ways: traditionally (smallholder scale) and industrially. Cocoa in Côte d'Ivoire is grown by around 600.000 to 900.000 farmers, predominantly smallholders, with up to 6 million dependents [i]. The cultivation of this crop thus impacts many Ivorian lives.

Main regional differences

Regions with the highest production of dried beans are Guémon, San Pedro and Cavally. Cocoa pods are most available in these regions. Below map shows an overview of the available volumes of cocoa pods per region.

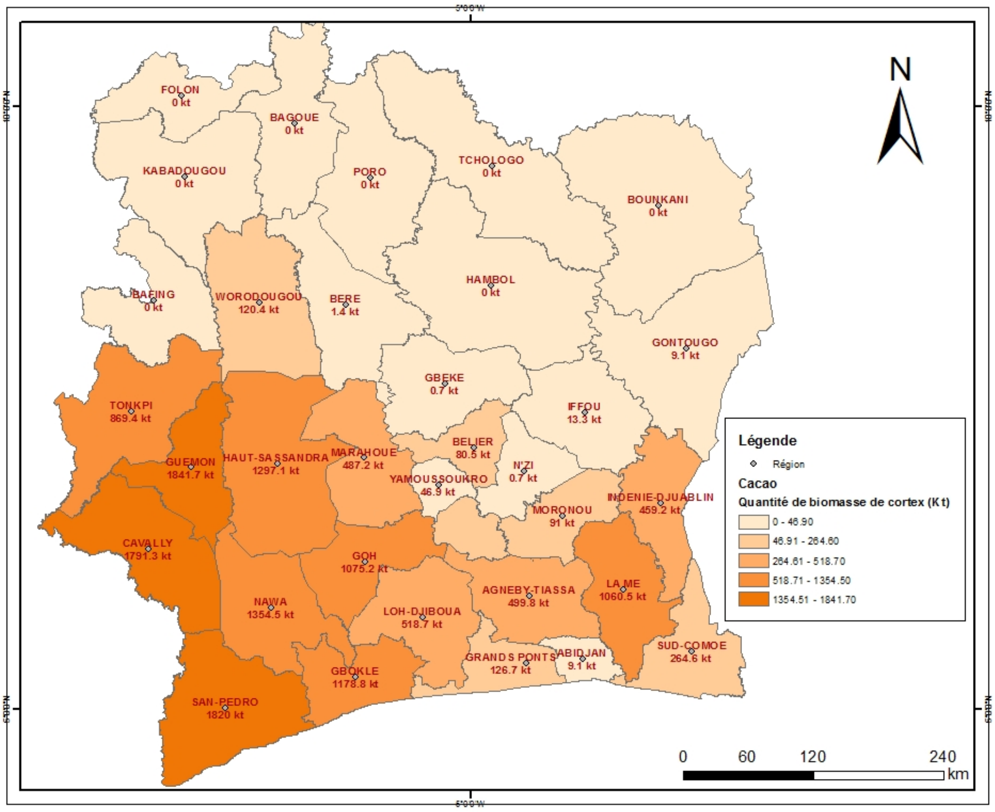

Figure 10 Quantities of cocoa pods per region

Source: interviews with Conseil Café-Cacao, Solidaridad and LONO.

5.2 Production process

Figure 8 shows schematically the cocoa production process and resulting residue streams.

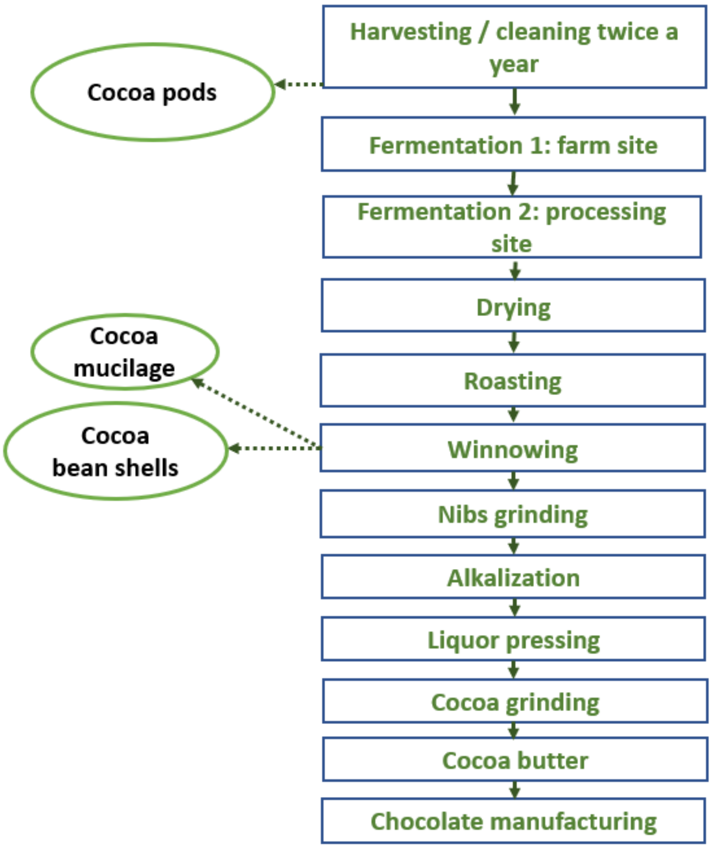

Figure 8 Overview of production process of cocoa (adapted from ICCO)

5.3 Residue availability

Cocoa pods and bean shells are identified as main residues in terms of valorisation opportunity. This identification is based on availability, characteristics and existing usage or application of cocoa production residue streams. Both residues occur at different stages of the value chain and at different locations. Pods are generated at beans harvesting, while shells result at processing. Figure 8 provides a schematic overview of cocoa processing steps and resulting residue streams.

Cocoa pods

Research by Solidaridad [ss] suggests that 1 tonne of dry cocoa beans yields about 7 tonnes of empty pods. There was a total potential of 15 million tonnes in 2019 in Côte d'Ivoire, corresponding to an energy potential of 90.000 GWh (324 million GJ). Empty cocoa pods or cortex represent the bulk of the cocoa residue in terms of mass. At small production sites, pods are scattered on the ground and play an agronomic role in returning organic matter to the soil. Large producers avoid the cost of returning pods to the plantation site by piling up empty pods at the shelling location. Piling up pods creates a quasi-anaerobic condition, which leads to methane emission [b]. Left unutilized, these piles therefore pose an environmental risk. Greenhouse gas emissions from the uncontrolled disposal of cocoa pods has seen a steady increase in Cote d'Ivoire since 1961, corresponding to the increase in production of cocoa beans. Average CO_2eq emissions in the last ten years from 2007 to 2017 were estimated to be about 19.000 ktCO_2eq/annum for Cote d'Ivoire. Valorisation of empty cocoa pods could mitigate this effect.

The regions of Guémon, San Pedro and Cavally account for the highest cocoa cultivation. These regions are therefore suitable areas for the establishment of cocoa pod farming units. Establishment of such units would serve to minimize transport costs for mobilization of the raw material.

Cocoa bean shells

Mass of cocoa bean shells is estimated at between 12%[b] [aa] and 17%[k] of the mass of dry beans. Cocoa bean shells result at grinding facilities. Cocoa bean shells thus occur largely in Europe[aa], where 36% of global cocoa grinding takes place. Large cocoa producing companies such as Olam are increasing domestic processing capacity in Abidjan and San Pedro[9]. ICCO estimates 614 TMT cocoa beans to be grinded in Côte d'Ivoire in 2019/2020 [p]. Domestic grinding facilitates domestic utilisation of cocoa bean residues. Using the estimates of 12% and 17% of mass of dry beans, the amount of cocoa bean shells available domestically can be estimated at 89TMT.

Transport vessels shipping cocoa beans to Europe, often return empty [fff]. This existing infrastructure provides an opportunity to load these vessels with cocoa bean shells and ship these back to Côte d'Ivoire for domestic valorisation.

5.4 Potential valorisation routes and related sustainability aspects

To identify potential valorisation routes within the cocoa value chain, energy demand per cocoa bean processing step was mapped (see annex H: inventory of biomass demand). During cocoa processing, the most energy-intensive operations identified are pressing and grinding, which account for 58% and 26.3% of the total energy used. For all unit operations involved in the processing of cocoa bean powder, the diesel generator used as an energy source consumes the most energy. Below table provides an overview of by-products, current use, energy potential, and other potential applications.

Table 6 Applications and heating value of cocoa by-products

Waste stream	Current application(s)	Potential energy application	Low Heating Value kJ/kg	Comments
Cocoa bean shells	Some existing examples of steam boiler fuel use.	Steam boiler fuel fertilizer cattle feed	15.500	Occurs at processing sites, 36% of which are in Europe.
Cocoa pods	Some existing examples of bio-charcoal production	Charcoal for cooking biogas production pellets (for trade) fuel for steam boilers	n/a	Charcoal production feasible for local communities

[9] https://www.olamgroup.com/locations/africa/cote-d-ivoire.html

Cocoa pods

Bio charcoal production

Cocoa pods are less suitable as a biomass source for production facilities, due to two factors. First, the moisture content of cocoa pods is relatively high, which means an additional drying step would have to be introduced before effective combustion is possible. Second, the spatial dispersion of the collection points drastically increases transport costs. Cocoa pods are therefore more suitable for small-scale, local applications. Bio-charcoal or briquette production offers such a solution.

Bio charcoal is produced in an artisanal way on-site. The carbonisation process of the empty cocoa pods is carried out in a pyrolysis reactor. Empty cocoa pods are fired for 8 hours under pressure for partial combustion. The component obtained at the end of the oven is a carbonised material that goes to composting. After composting, the carbonised material is consolidated with a natural binder (filtered cassava starch) and then sun-dried. The production of 40 kg of carbonised material requires 118 kg of dried empty cocoa pods. In addition to energy production and pollution control, biochar can be an effective way to combat deforestation.

Sustainability and risks

Deforestation is a major problem in Côte d'Ivoire. The use of charcoal for cooking is the second most important cause of deforestation. 69% Of the population uses charcoal for cooking [j]. This figure is slightly lower around Abidjan, where it is about 42% and about 40% use butane gas instead). Ivorian households consume on average 4 kg fuelwood or 2 kg of charcoal per day, which is the equivalent of 5 kg of fresh wood; this implies new felling every day. Sustainable fuel substitution is therefore of utmost importance. For conventional cooking, a sustainable alternative to charcoal can be made from cocoa pods. Most clean cookers are operated with wood pellets.

Cocoa cultivation has been linked to deforestation. In utilising residue streams of cocoa production, scrutiny must be applied to make sure valorisation mitigates this risk and does not contribute to deforestation and land use change.

Cocoa bean shells

Steam boiler fuel

Cocoa bean shells are a viable steam boiler feedstock for heat generation required for sterilisation, roasting and grinding in cocoa bean processing. Other industries that require heat for processing could also benefit from using cocoa bean shells as feedstock to meet renewable energy requirements. Some cocoa producing companies such as Olam, JB Cocoa and Barry Callebaut fulfil part of their energy demand at production sites by combustion of cocoa bean shells.
Cocoa bean shells are sometimes traded as a commodity. This leads to a fluctuating purchase price. Depending on the purchase price, energy consumers may be reluctant to use cocoa bean shells as a biomass source . Cocoa producing companies are well positioned to use their own cocoa beans shells as a biomass source at processing sites. Cocoa producing companies with renewable energy targets are likely to exploit this option. Cocoa processing plants are often located in remote areas with little or no access to fossil fuels. This can stimulate the use of cocoa shells as a biomass source.

Biochar production

Cocoa bean shells can be used to produce biochar. Biochar serves as an organic fertilizer and has carbon capture properties. Biochar production releases energy that can power grinding and pressing at a cocoa production site. Dutch TNO is engaging with Olam to develop this application further [fff]. Olam has announced interest to engage further with TNO, if the energy/ biochar ratio (Currently 80-

20) can be increased. Cocoa producer Barry Callebaut is producing biochar at several of their production sites. Biochar installations can be costly, and skilled operating staff must be available on site.

Sustainability and risks

Combustion properties are species-specific and site-specific[10]. Fertilization and soil characteristics impact ash content and ash melting, fouling and slagging temperatures, as well as emissions. These characteristics must be evaluated thoroughly for each potential location.

Cocoa bean shells are rich in protein as well as dietary fibre [v]. The viability of applications for animal feed or human food production should be explored to avoid risk of competition. Feed and food applications could also constitute an additional source of income for cocoa producers[11].

Ongoing initiatives/ businesses

- Several local initiatives have been founded that produce bio-charcoal from cocoa pods. The Association des Propriétaires de Forêts Naturelles et Plantations d'Affery (APFNP), the main actor in the production of bio-charcoal, continues to research new formulas and agricultural commodities to increase local production.
- Large cocoa producers such as Olam, Cargill, Barry Callebaut, and JB Cocoa already use cocoa shells as a biomass source in their cocoa production plants.
- TNO has been working on a cocoa bean shell biochar pilot with Olam [fff].
- Dutch company Infratec builds charcoal furnaces and works with different residue streams [ddd]. These can be adjusted to scale, making small local applications possible.
- Ivorian company Nawa Bio Energy transforms cocoa pods into bio charcoal.
- Several Ivorian universities mentioned in chapter 2.2 have ongoing research projects.

[10] https://www.vyncke.com/industries/agro-food/cocoa/
[11] https://www.jbcocoa.com/wp-content/uploads/2019/04/3715163150JB-Foods-Limited-Annual-Report-2017.pdf

6. Palm oil

6.1 Short outline of the sector in Ivory Coast

Production volume and characteristics of the sector

Côte d'Ivoire is the second biggest African palm oil producing country[12], surpassed only by Nigeria. On a global scale, CdI ranked 11th in palm oil production volume with an annual production of 515.000 MT in 2020. Indonesia and Malaysia continue to lead this chart with respective production of 43.500.000 MT and 19.900.000 MT[13] . The Ivorian government has formalised plans to increase crude palm oil production in the national agricultural investment program (Programme National d'Investissement Agricole - PNIA)[14].

Structure of the sector

There are two main ways of oil palm cultivation in Côte d'Ivoire: traditional and industrial. A perennial crop native to Côte d'Ivoire, oil pam has been cultivated in the traditional way for thousands of years [x]. Traditional palm oil production sources fresh fruit from wild oil palm groves and small-scale farms. A small-scale farm covers up to 50 ha of land [ff]and often does not apply modern agronomic practices such as fertilizing and cover cropping. This practice has an average palm oil yield of 5-8t/ha (FARM 2020). In Côte d'Ivoire more than 70% of oil palm producers are small producers. Industrial oil palm cultivation makes use of large-scale plantations and crude palm oil mills. Industrial plantations cover 75.000 ha (FARM 2020), with a significantly higher yield of 12 t/ha.

A brief overview of the oil palm sector in Côte d'Ivoire in 2019, according to the Roundtable on Sustainable Palm Oil [ff]:

- 2.445.000 tonnes of oil palm bunches
- 536.000 tonnes of crude palm oil
- 220.000 ha of village plantations
- 75.000 ha of industrial plantations
- 44.866 oil palm planters
- 32 cooperative societies members of the National Federation of cooperative societies and unions of cooperative societies of Palm Oil Planters of Côte d'Ivoire (FENACOPAH-CI)
- 16 large Palm Oil Mills with a total installed capacity of (600 t/h)
- 20 small and medium Palm Oil Mills with a total installed capacity of (180 t/h)

The RSPO defines smallholder farmers in Côte d'Ivoire as follows [ff]: Farmers cultivating oil palm, sometimes with subsistence crops, labour can be provided by the family, the farm providing the main source of income, the area planted with oil palm being less than or equal to 50 ha.
Smallholders may be formally bound by contract, credit commitment or attached to an oil mill, the association not necessarily being limited to these links. In Ivory Coast there are no associated smallholders. Smallholders who are not formally bound by contract, credit commitment or attached to an oil mill are known as independent smallholders. In the Ivory Coast more than 70% of oil palm producers are small producers.

6.2 Overview of production process steps and related energy use

In the CPO production process, cracking and oil extraction require a relatively high energy input. These steps have a relatively higher potential for bioenergy applications. Most companies have

[12] https://www.indexmundi.com/agriculture/?commodity=palm-oil
[13] https://www.indexmundi.com/agriculture/?commodity=palm-oil
[14] https://www.palmafrique.com/en/palm-oil-in-the-ivorian-economy/

biomass boilers that allow the combustion of part of the solid waste to produce steam required for the oil extraction process. Large plants such as Dekel Agrivision and Palm-ci have steam turbines for biomass cogeneration. Below figure provides a schematic overview of the CPO mill production process.

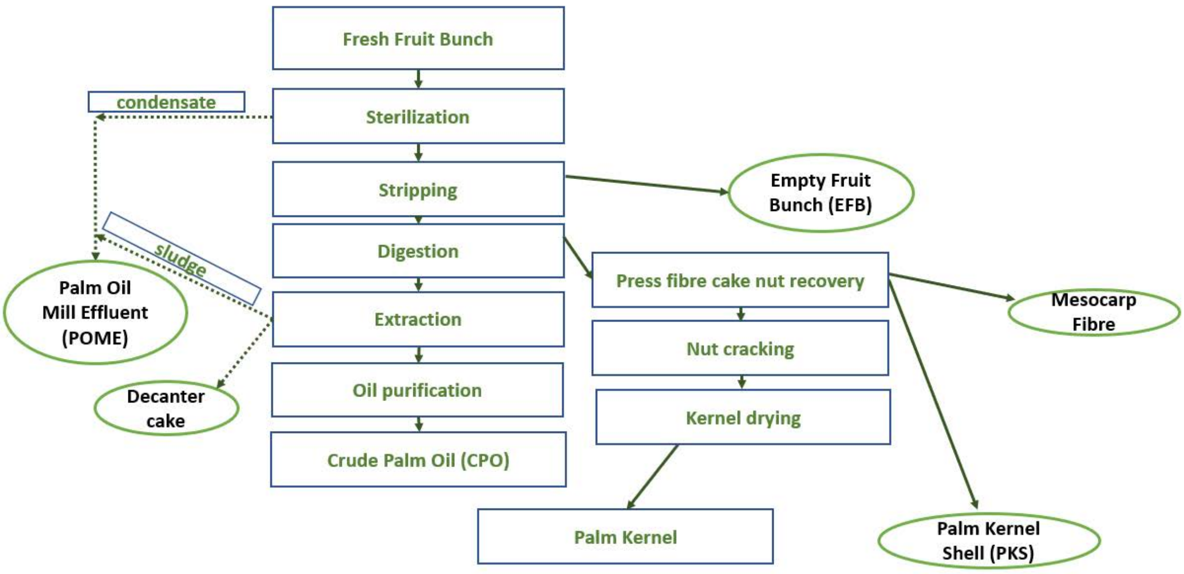

Figure 8 Overview of production process CPO mill (adapted from FAO)

6.3 Residues and valorisation potential

Out of the different byproducts resulting from CPO production, several are already to some extent used within the value chain. Below is an overview of the biomass streams that have the most significant potential for energy usage, their current application and their potential. Oil palm tree trunks, fronds and press cake are noted as a residues, but were not further analysed in this study.

Table 7 Applications and heating value of palm oil by-products

Waste stream	Current application(s)	Potential energy application	Low Heating Value kJ/kg	Comments
EFB	Plantation fertilizer	Pellets (for trade)	4.300	Due to salt and mineral content, pre-treatment or adapted boilers required for further conversion
POME	No application currently	Biogas/bio methane production for powering CPO mill	n/a	Detrimental environmental effects if left unused due to methane emission
PKS	On-site CPO mill steam boiler fuel supplementing fibres. Traded internationally	fuel for steam boilers	15.500	Efficient use as steam boiler fuel for co-firing
Mesocarp fibres	On-site CPO mill steam boiler fuel	Pellets (for trade)	10.300	Efficient feedstock for pelletisation if POME could provide power to CPO mill instead

Empty Fruit Bunches (EFB)

EFB waste occurs on the mill site and is partially returned to the plantation as fertiliser. In some cases, EFB is incinerated, which causes pollution. Due to its high salt and water content, EFB requires pre-treatment such as washing and drying for alternative applications such as pelletising or combustion adapted boilers.

Palm Oil Mill Effluent (POME)

In industrial mills, the Palm Oil Mill Effluent POME is treated in large, open ponds. Various POME treatment processes exist. The most widespread and least costly is lagoon treatment. This consists of a series of anaerobic and aerobic basins that allow the biochemical oxygen demand to be lowered to a level that complies with the regulations. During anaerobic treatment, gases including methane are released into the atmosphere. Open POME ponds therefore constitute a source of GHG emissions, as these ponds emit methane (CH_4) directly into the air.

Some industrial units discharge their effluent without treatment into the watercourses where they are located. Anaerobic digestion of POME in oil mills could provide biogas to meet the energy demand of a CPO mill. Currently, mesocarp fibres are burnt for this purpose. If CPO mills were to start operating on biogas, the mesocarp fibre could be considered as a potential feedstock for biochar production or pelletisation, thus optimising the value and use of both residue streams. The digestate from the POME can be returned to the field as fertiliser.

The volume and composition of POME varies greatly depending on the composition of the fresh fruit bunch, processing scheme, processing conditions and the separation efficiency. In this study, the amount of POME and related energy potential was estimated from the amount of water needed to process one ton of fresh palm fruit [s]. Studies suggest this amount varies between 5 to 7 m^3 of fresh water. Literature suggests that POME accounts for between 50% and 79% water used. Since the production of POME is linked industrial palm oil production, the quantities of POME were estimated for the regions where the processing industries are located, based on the operating capacity of these plants. Further to this estimation, it is assumed that 1m3 of POME produces 28 m^3 of biogas.

Region	Location	Mill operator	Capacity (t/h)	Capacity (t/an) Estimate	Biomasse POME (x 1000 m^3) Estimate
Abidjan	ELOKA	PALMAFRIQUE	30	100 000	309
Agnéby-Tiassa	SIKENSI	ADAMAFRIQUE	45	150 000	464
Bas-Sassandra	DABOUYO	CODIPALM	30	100 000	309
Gbôklê	BOLO	SIPEFCI	60	200 000	619
Grands-Ponts	IROBO	PALMCI	60	200 000	619
	YASSAP	PALMAFRIQUE	50	165 000	515
	GRAND-LAHOU/YOCOBOUET	HSB	20	66 000	206
Lôh-Djiboua	BOUBO	PALMCI	75	250 000	773
	DIVO	OAIC	29	95 700	299
	GUITRY	CODIPALM	24	80 000	248
	DIVO (Brabodougou)	ETRAPCI	27	90 000	278
Mé	WROUWROU/ALEPE	SPDO	20	66 000	206
Nawa	OTTAWA (SOUBRE)	SIPEFCI	60	200 000	619
San-Pédro	IBOKE	PALMCI	45	150 000	465
	BLIDOUBA	PALMCI	30	99 000	309
	GBAPET	PALMCI	20	66 000	206
	NEKA	PALMCI	30	99 000	309
	GRAND-BEREBY	SOGB	45	150 000	464
Sud-Comoé	EHANIA CENTRALE	PALMCI	90	300 000	928
	EHANIA ANTENNE 1	PALMCI	30	99 000	309
	EHANIA ANTENNE 2	PALMCI	30	99 000	309
	TOUMANGUIE	PALMCI	55	182 000	567
	AYENOUAN (ABOISSO - BONOUA)	DEKEL OIL	60	200 000	619
	MOUYASSOUE	API	20	66 000	206
	Total		**985**	**3 250 500**	**10 157**

Figure 10: Estimation of POME availability based on mill locations and their production capacity as provided by Conseil Hévéa-Palmier à Huile. This list contains all mills with a capacity of 20t/h or higher.

Mesocarp fibres

See annex 1.3 and above paragraph on POME. Not further analysed in this final report due to existing usage.

Palm Kernel Shells

PKS are an internationally traded commodity and considered a valuable feedstock for co-firing globally. In some cases, PKS are used on site to complement mesocarp fibres in the steam boiler.

Selling PKS could be an additional source of income for palm oil producers. Not further analysed in this final report due to existing trade.

Availability and regional differences

In 2016, there was a potential of 118 kilotonnes of PKS, 495 kilotonnes of EFB and 283 kilotonnes of mesocarp fibres corresponding to an energy of 2035 Gigajoules, 8507 Gigajoules and 4928 Gigajoules respectively. The highest biomass potential is recorded in the regions of Sud-Comoé and San Pedro. The figures presented below stem from 2016. Figures retrieved for 2019 from the palm oil board did not specify regional characteristics.

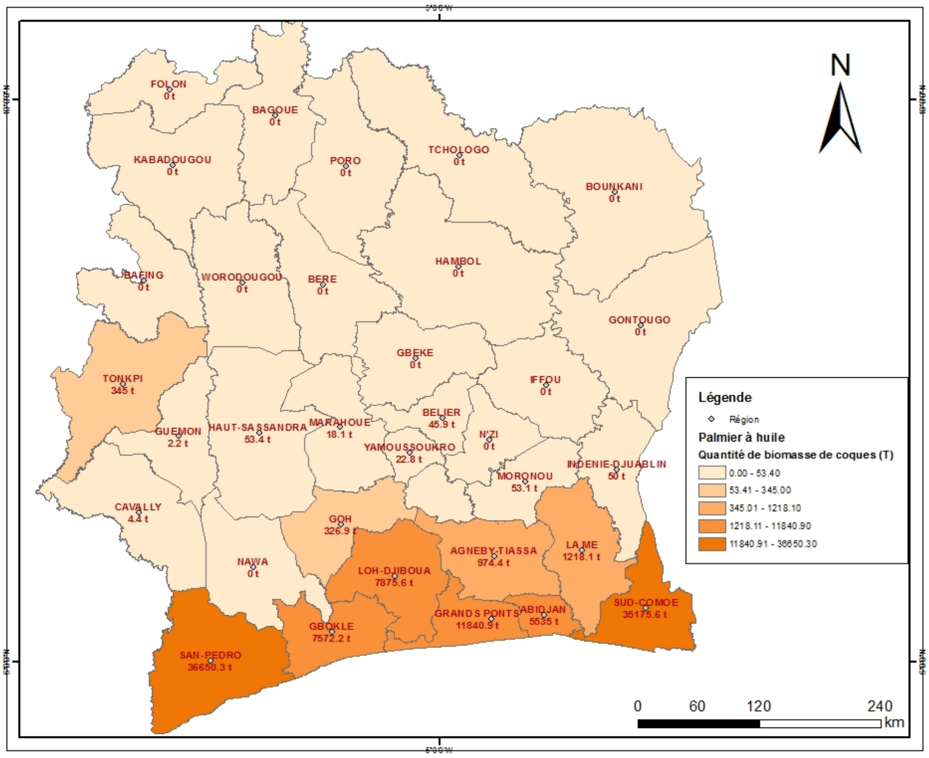

Figure 11 : Production of PKS in the regions of Côte d'Ivoire

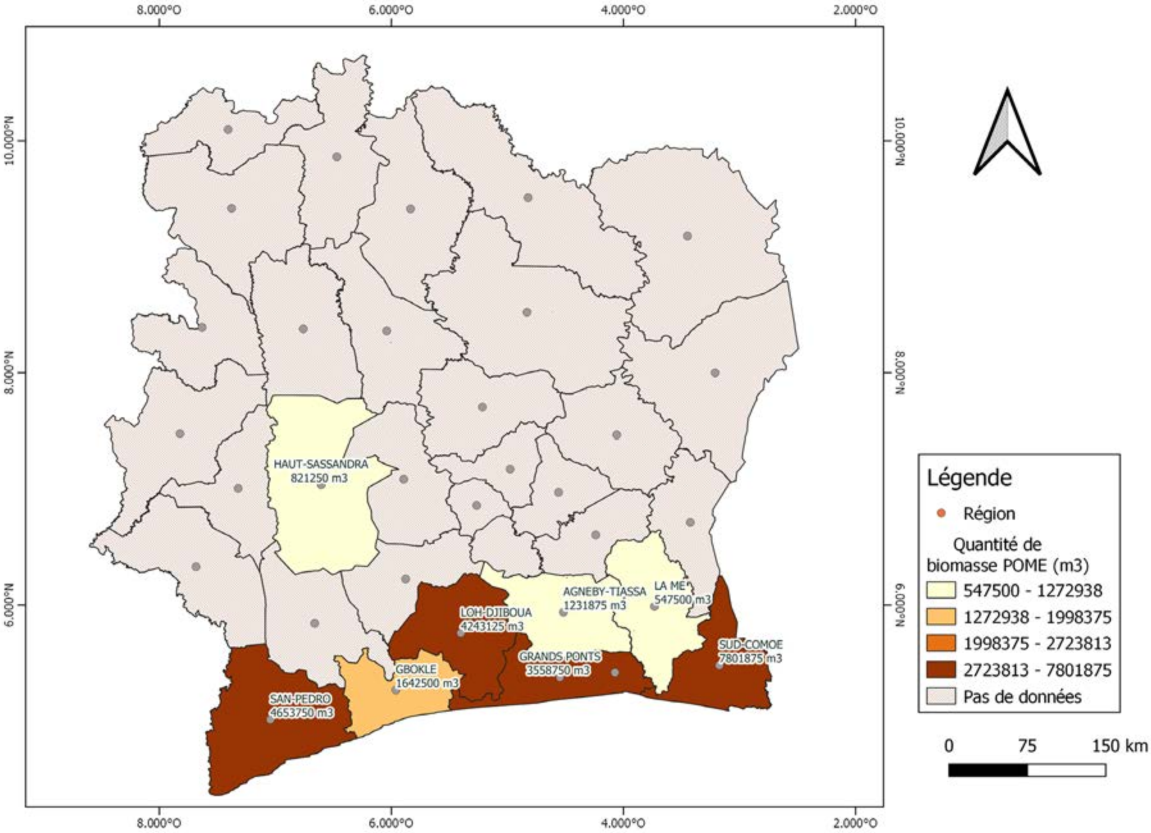

Figure 12 : Production of POME in the regions of Côte d'Ivoire

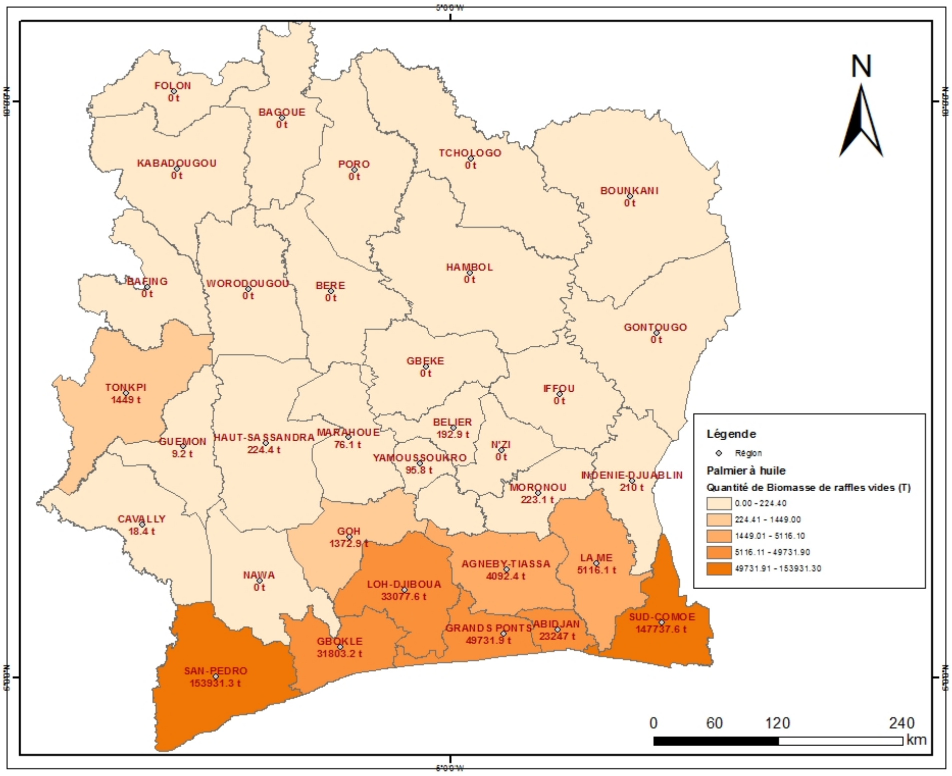

Figure 13 : Production of EFB in the regions of Côte d'Ivoire

Ongoing initiatives

- French development bank Proparco financed a 46 MW Ayebo biomass plant running on oil palm waste[15]. Developer is Biokala, a subsidiary of the SIFCA group;
- Ivorian company LONO is working on a feasibility study on palm waste with Dekel oil;
- SOCFIN is exploring opportunities for palm waste valorisation.

6.4 Sustainability

When engaging in the palm oil value chain, social and environmental sustainability risks must be monitored closely. Palm oil production has been linked to deforestation, community displacement and labour misconduct. When engaging with palm oil mills, it is important to confirm sustainability measures as well as certification.

[15] https://www.afrik21.africa/en/ivory-coast-proparco-finances-ayebo-biomass-power-plant-project-46-mw/

7. Rubber

7.1 Short outline of the sector in Ivory Coast

Production volume and characteristics of the sector

In 2020, the rubber sector in Côte d'Ivoire has reached a production of 955.571 tonnes, an increase of 23% as compared to 2019 (780.051 tonnes) [ii]. The country is the largest rubber producer in Africa and ranks fourth in the world, after Indonesia, Thailand and Vietnam[16].

Structure of the sector

The plantations are mainly village based (89% of the total surface area, 65% of national production), bringing together more than 170.000 farmers according to the report "Technical Studies of Biomass Power Plants" carried out in 2020 on the basis of data from the last census of agricultural land in 2016 by Innovation Energie Développement (IED). Some large plantations are owned by agro-industrial complexes, an overview is provided in the table below.

Table 8 Overview of large rubber plantations in Côte d'Ivoire

Name	City
ASAF Industry	Azaguié
CCP	Douboury
CHC	Zagné
CTC SOGB	Heké
EXAT (2 plantations)	Taboo, San Pedro
Hevetec	Sikensi
ITCA	Dabou
SAIC	Aniassue
SCC	Adaou
SIAT CHP	Prikro
Société Africaine de Plantations d'Hévéas (SAPH), five plantations	Aboisso, Bétié, Toupah, Yacoli Tahoré
TRCI	Abidjan
Wood and Latex	Zagne

Main regional differences

Hevea production is mainly concentrated in the south of Côte d'Ivoire. There are two important production centres: Cavally - San Pédro in the South-East, and Grands Ponts - Abidjan - Sud Comoé in the South-West.

The following figure shows the biomass potential of rubber seeds by region.

[16] https://www.agenceecofin.com/caoutchouc/2503-86529-cote-d-ivoire-la-production-de-caoutchouc-naturel-a-atteint-950-000-tonnes-en-2020

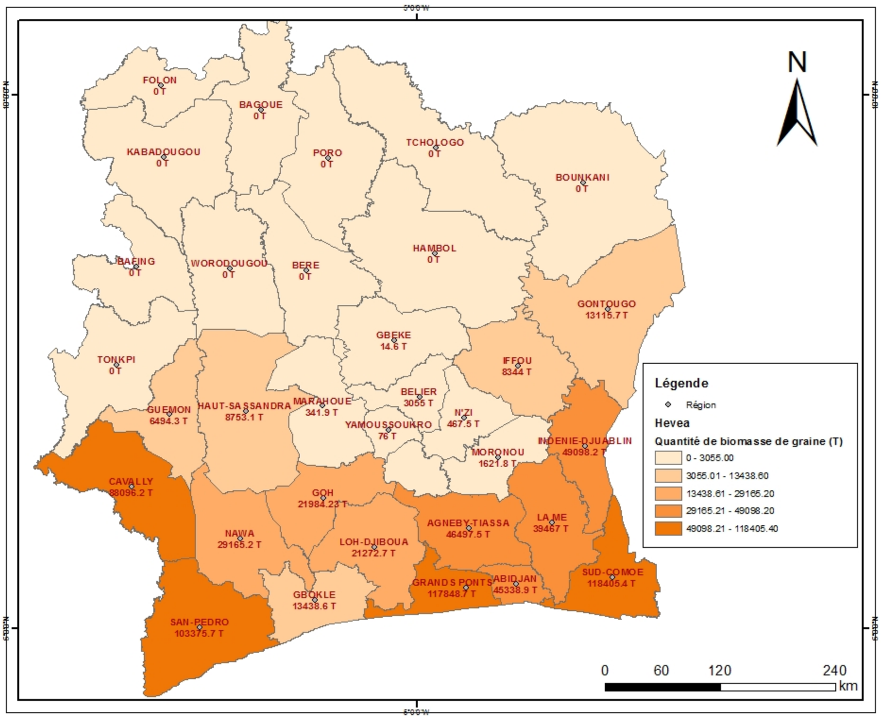

Figure 14 Potential per region for the production of vegetable oil from rubber seeds

Ongoing initiatives

The government of Côte d'Ivoire has recently announced a first project targeting the valorisation of rubber seeds[17]. As part of the project a production unit will be developed to transform rubber tree seeds into biodiesel in the region of the Grands Ponts and more specifically in the locality of Dabou. This project, in which the government of Côte d'Ivoire (through its rural development agency ANADER) cooperates with the Swedish development agency Swedfund and the company Scania. Additionally, the Ivorian companies LONO and SOGB are exploring opportunities for the valorisation of waste from rubber plantations.

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17 http://www.anader.ci/production_de_biocarburant_en_cote_d_ivoire_vers_l_installation_d_une_usine_de_production_a_dabou.html

7.2 Overview of production process steps and related energy use

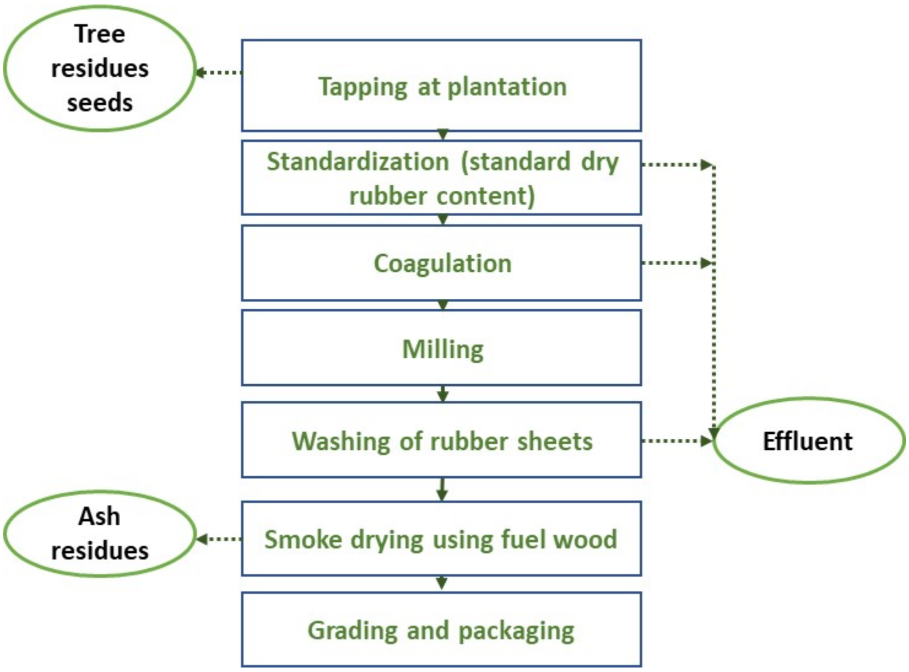

Figure 15 Process steps in natural rubber production

The final product is mainly used for tyre manufacturing.

Potential energy use within the rubber processing value chain

Firewood is used to generate heat and smoke in the smoking chamber. The most commonly used firewood is para wood. In addition, diesel fuel is used to run the engines for the milling step. If we look at the proportion of electrical energy and thermal energy consumption used to produce the rubber sheet, we can see that thermal energy accounts for most of the total energy consumption, i.e. more than 80%. The main heat resource is firewood, which accounts for 69% of total energy use of the process.

By-products of rubber production

Leaves, branches and trunks from maintenance and felling residues

Pruning is rarely practised in the rubber tree exploitation cycle. However, rubber trees are very sensitive to violent gusts of wind, resulting in damaged and uprooted trees throughout the year. Damaged trees are removed from the plantation. This yields small amounts of biomass dispersed throughout the plantations. A litter of fallen rubber tree leaves also forms in the plantation. Leaf biomass is estimated at around 6 tonnes of dry mass per hectare per year. These leaves are returned to the soil and contribute to its fertility.

For industrial plantations, a strict renewal cycle of 35 to 40 years is respected where all trees are removed to establish a new plantation. In the case of SAPH, for example, this leads to an annual average of 3% of their rubber trees that are being renewed. These renewal rates have however been much lower or even nil in recent years due to the low price of rubber. Felling residues resulting from these renewals represent between 175 and 250 tonnes per hectare [g]. Most of the time they are removed from the plantation and burnt. Some millers valorise them as biomass energy, but the lack of outlets limits the number of initiatives to isolated cases. As an example, the SAPH agro-industrial complex near Abidjan rents a crusher to grind its felling residues and sells them to Abidjan factories equipped with boilers.

Rubber trees provide high quality wood, felling residues could hence be valorised at higher prices as timber, as is the case for example in Thailand, where the plantation renewal cycle is shorter (20 years) in order to optimise benefits from the sales of the felling residues. The lack of a developed timber sector in Côte d'Ivoire however complicates this valorisation option. In village plantations, rubberwood is used as fuelwood, particularly for charcoal production and cooking.

Felling residues could represent a very interesting source of biomass, especially in agro-industrial complexes where they come available in considerable quantities and are currently predominantly being burnt as a waste disposal option.

Effluents

The rubber production process as depicted in Figure 16 comprises several process steps (including standardisation, coagulation, milling and washing) that lead to wastewater effluent with a high organic matter (notably phosphorus and potassium). Currently these effluents pose a waste issue, they are treated in basins for bacteria to digest the organic matter, after which they are discharged.

Seeds

As far as seeds are concerned, each tree in full yield provides between 700 and 800 seeds per year, which translates into an average production of rubber seeds per hectare of around 1.461 kg. Rubber seed oil yields are in the range of 44%, i.e. 643 kg/ha [v]. For total production estimates and further details, please refer to Annex G.

Energy potential of by-products of rubber production

In the following table, lower heating values are provided for the main by-products described above.

Table 9 LHV of rubber tree residues (sources: [v] and [m]

By-product	LHV (MJ/kg)
Woody residues	17,6
Seeds (total kernel)	24,0
Crude oil from rubber seeds	35,2

Total calculated availability of felling residues (taking into account the aforementioned 3% renewal rate), amounts to 2.645.674 tonnes. Total calculated potential of crude oil production amounts to 157.120 tonnes.

7.3 Valorisation potential of by-products and related sustainability aspects

Tree residues

Environmental aspects: emissions, climate impact, cascade and land-use

The current productive use of felling residues from rubber trees is scarce, and common practice is burning in the field as this is the easiest and lowest cost disposal route. Valorisation of this biomass source would contribute to reduction of climate impact by avoiding CO_2-emissions from uncontrolled burning of tree residues and – depending on the application - through substitution of (fossil or other) energy sources with woody residues based biomass.

In addition, when substituting fuelwood, application of this source would have a positive impact on reducing deforestation and related loss of biodiversity.
From the principle of cascading use of biomass, material application of the part of the felling residues that can be used as timber would be preferred but is deemed to be complex due to a lack of infrastructure/ market opportunities. This could however be further explored.

Socio-economic aspects/working conditions

Setting up the logistics and processing of felling residues into easier transportable fuel types could entail employment options, potential use as timber would require setting up an infrastructure that would require the setup of new businesses to develop this value chain.

Rubber seeds

Environmental aspects: emissions, climate impact, cascade and land-use

According to a recent study into the CO_2-footprint of biodiesel on basis of rubber seeds, a positive CO_2 impact of 67 g CO_2eq/MJ [gg] can be achieved as compared to fossil diesel (representing a potential of 2,8 tonne CO_2-reduction per substituted tonne of diesel).
With regard to potential in terms of cascading use of biomass literature shows that rubber seed oil has potential high end application possibilities for instance as a basis for coatings. Developing the value chain for rubber seeds may hence at a later stage provide access to higher value markets.

Socio-economic aspects/working conditions

The valorisation of rubber seeds through production of biodiesel entails setting up a new value chain with a range of processes and related employment and entrepreneurial perspectives – from the collection of the seeds in the field to the marketing of the final product. In the framework of the announced pilot project, ANADER estimates a permanent creation of 420 new jobs as well as work for an estimated 10.000 season workers collecting the seeds.

7.4 Productive use cases and related business opportunities

Tree residues

As a first step the potential valorisation of tree residues as an energy source (for instance for the smoke-drying step in the rubber production process) is to be explored as a more sustainable alternative to current disposal by burning in the field. The business opportunity posed by producing timber from rubber tree felling appears complex due to the current lack of market infrastructure but could prove to have business potential as a consequence of the added value compared to fuel applications.

Rubber seeds

Depending on the experience that will be obtained with the first pilot project of the ANADER / Swedfund / Scania consortium in Dabou, replication potential can be assessed and would require additional actors to enter the market in order to realise the full potential of the value chain.
The set-up of a recovery infrastructure can be initiated in parallel, since the seeds can also directly be applied in lower end applications, including as a direct fuel with a calorific value comparable to (somewhat higher) fuel wood. The value chain for the rubber seeds can then be further developed to service applications of an increasing added value – as feedstock for biodiesel and as a building block for green chemistry (e.g. application as main basis component for surface coatings).

8. Conclusions and Recommendations

8.1 Cashew

Conclusions

Cashew shells / CNSL

CNSL production has previously taken place in Côte d'Ivoire at three larger processing factories, however due to the low price of CNSL there is currently no business case for the production of CNSL for the (inter)national market. However, direct application as a fuel – either as single fuel or in a mixture with another fuel type, such as DDO – might pose a valid business case. This route is currently being explored by CBI in cooperation with Away4Africa, Funteni and Nitidae [yy].

Direct use of the shells is discouraged due to the toxic fumes that may arise, however an alternative processing route is the production of briquettes that can be applied in cookstoves or boilers through (controlled) pyrolysis.

In view of the impressive growth in processing capacity in Côte d'Ivoire (leading to a considerable larger volume of shell residues), when successful the potential of scaling up is huge and expected to grow further in the coming years.

Cashew Apples

The cashew apples provide a vast untapped potential of a product that has numerous application possibilities in the food and energy sectors. In Côte d'Ivoire, currently only 1% of the cashew apples is used as a food product, of which 0,9% is used for direct consumption and 0,1% is processed into juice/beverages [c]. The remaining 99% is left in the field, causing considerable methane emissions (a greenhouse gas 22 times more powerful than CO_2) as part of the fermentation/decomposing process.
To be noted is that the current 1% productive use represents an already considerable estimated volume of 95.700 Mt cashew apples. Upscaling to for instance 12% (the share of cashew apples currently processed in Brazil) would imply a processing capacity of 1.148.400 Mt.
The process of juice production has significant advantages over direct consumption as it enables longer conservation and entails the possibility of further processing into products with a high added value.

Recommendations

Cashew shells/CNSL

- Explore options to support the initiative coordinated by CBI to produce CNSL for direct productive use. This could for instance take shape through optimising the valorisation route of the press cake that is the main by-product of CNSL production.
- Initiate a pilot project for valorisation of the shells through pyrolysis. Several technology developers in the Netherlands have a strong expertise in this technology (see also the stakeholder overview compiled for this study). This pilot would require:
    - pitching the opportunity among potentially interested Dutch technology providers;
    - matchmaking with local counterparts (knowledge and value chain partners required for the pilot project in Côte d'Ivoire);
    - Acquiring finance for the pilot, including investment in a small-scale pyrolysis installation. The pilot should include assessing applications for the briquettes and by-products in order to optimise the added value created.

Cashew apples

- Further research into critical success factors of cashew apple juice production in combination with productive energy use of residues (e.g. based on experience in Brazil where 12% of apples are processed, which is mainly linked to the variety used, which has better resilience to damage from falling from the tree) [a]. In addition, the possibility of applying alternative harvesting methods could be explored.
- Assess possibilities of attracting (carbon) finance in view of avoided methane and CO_2-emissions.
- Initiate a pilot project in a cashew plantation willing to participate and make available a test plot at which different ways to prevent damage to the apples can be trialled and evaluated. This pilot would initially be targeted at increasing the yield of undamaged apples. A possible follow-up could then be targeted at creating processing capacity.

8.2 Cassava

Conclusions

Cassava peelings

Cassava peelings, both from artisanal and from industrial processing do not pose an environmental issue as they generally find their way to different applications (mainly livestock feed), competition with this application should be avoided. Where applicable, small-scale biogas could be a viable option to replace firewood used in the boiling step of cassava production processes. This would contribute to reducing negative health and environmental impacts and has a potential of creating additional business opportunities, including for female entrepreneurs.

Cassava sludge from (semi-)industrial processing

Sludge from industrial cassava processing currently poses an environmental issue as well as a significant cost item for the sector. Producing biogas may contribute to addressing both issues, however this will still result in a residual stream – potentially this digestate can serve as a fertilizer, however due to the quantities finding sufficient outlets is not evident.

Recommendations

- Explore options to promote implementation of biodigesters in traditional cassava processing;
- Based on a further inventory of larger scale cassava processing plants, assess possibilities and subsequently viability of on-site biogas production, involving Netherlands' technology partners where appropriate. A case study conducted in Nigeria in a larger scale cassava starch processing plant indicates that considerable cost-savings are possible, resulting in a relatively short payback period. This inventory would require pitching the opportunity among (larger-scale) Ivorian cassava starch producers, matchmaking with Dutch technology providers where appropriate and a first global assessment of the feasibility of biogas production and productive use in the particular plant (as feasibility depends strongly on the energy balance of the plant and other local circumstances, such as costs of waste disposal).

8.3 Cocoa

Conclusions

Both industrial and small-scale cocoa farming provide opportunities for biomass residue valorisation.

Cocoa pods

In small-scale cocoa farming, cocoa pods are collected locally. This makes cocoa pods an ideal source for local valorisation. There is a strong need for a sustainable alternative to conventional charcoal for cooking, due to deforestation and health risks. Producing bio-charcoal from cocoa pods addresses deforestation in Côte d'Ivoire and provides opportunities for local employment. Therefore, the possibility to produce bio-charcoal from cocoa pods locally makes for a promising case to explore further.

Cocoa bean shells

Industrial cocoa processing allows for central collection of cocoa bean shells. Combustion of cocoa bean shells is a viable source of steam for local industry to meet renewable energy targets. Biochar is a valuable product for cocoa producers as carbon capture instrument and fertiliser. Both valorisation options add to circularity of the cocoa production process. Cocoa bean shells largely occur in Europe, as this is where 36% of cocoa beans are shelled. Local production capacity is being increased, and cocoa bean trade involves vessels returning empty to Côte d'Ivoire. Both developments provide opportunities to increase local valorisation of cocoa bean shells.

Recommendations

Dutch companies and knowledge institutes have been piloting applications for cocoa bean shells elsewhere. Dutch industry also holds knowledge on charcoal production. Cooperation on the subject between Dutch and Ivorian partners has so far been limited. Providing information to Dutch stakeholders on potential opportunities in the Ivorian cocoa sector is recommended as a basis for further collaborative follow-up.

Pods

In order to stimulate local production of bio-charcoal, it is recommended to:

- To facilitate start-up incubators for local bio-charcoal businesses;
- To initiate university exchanges to further develop the bio-charcoal production process (see stakeholder maps (E) for full details);
    - Institut de recherche sur les énergies renouvelables (IREN).
    - Institut National Polytechnique Felix Houphouet-Boigny (INPHB).
    - University Nangui Abrogoua (UNA).
    - Wageningen University and Research (WUR).
- To facilitate market orientation and matchmaking for Dutch charcoal equipment producers
    - Infratec (NL)
    - Nawa Bioenergy (CdI).

Cocoa bean shells

To further stimulate the valorisation of cocoa bean shells into steam or biochar at processing sites, it is recommended to:

- Stimulate investment in the development of local cocoa production sites to facilitate domestic valorisation, thereby contributing to Ivorian climate targets;
- Engage industry players mentioned in 5.4 that have an international infrastructure in place. Returning empty vessels provide an opportunity for returning biomass for local utilisation, making use of existing infrastructure;
- Support ongoing research by Dutch institutions (e.g. TNO) and consultancies (see stakeholder map (E) for full details);
- Provide matchmaking and market orientation activities for Dutch technology companies and Ivorian cocoa processing sites to explore business opportunities for combustion at processing sites.

8.4 Palm oil

Conclusions

Traditional oil palm cultivation provides less necessity and opportunity for large scale utilisation of biomass residues. Methane-emitting POME ponds are not prevalent, mobilisation of waste streams is difficult and local applications such as fertiliser and palm wine production are already in place. Our conclusions and recommendations therefore focus on industrial oil palm cultivation. In industrial oil palm cultivation, the following potential scenarios were identified as potentially promising.

POME & Mesocarp fibres

At the 24 largest (>20t/h) CPO mills in Côte d'Ivoire, open POME ponds are a huge source of environmental pollution. POME is not yet treated at Ivorian CPO mills. Anaerobic treatment is key to mitigate this issue. POME is a potential source of biogas for on-site power generation through anaerobic digestion. Currently, CPO mills co-fire mesocarp fibres as biomass source for on-site power, while characteristics of mesocarp fibres would be optimally used if pelletised. These pellets could then be sold locally or internationally. Implementing a biogas plant and pelletising technology requires significant upfront capital investment for CPO mills. Depending on specific market and local conditions, the resulting business case could be viable for industrial mills. This scenario improves circularity of the CPO production process and could have a significant positive climate impact.

PKS

At industrial CPO mills, PKS occur as a valuable residue with significant calorific value. PKS is in some cases traded internationally as co-firing feedstock for additional income.

Recommendations

POME & Mesocarp fibres

Dutch technology companies often are unfamiliar with the Ivorian network of palm oil producers. Recommendations therefore are as follows:

- To build relationships with industrial crude palm oil mill owners, such as:
    - Palm-CI
    - Dekel Agrivision
    - SIPEFCI
    - SOGB
- To facilitate showcasing of Dutch biogas and pelletizing technology in the Ivorian palm oil and biomass industries
- To provide matchmaking and market orientation matchmaking for Dutch technology companies and industrial palm oil producers to explore business opportunities for anaerobic digestion and pelletising. Dutch companies could include (see separate report: T1.1 stakeholder map for full rationale):
    - Paques
    - Yilkins
    - TNO

8.5 Rubber

Conclusions

Felling residues

Felling residues from storm damage and renewal of plantations form a considerable source of biomass in terms of volume and energy potential. Currently this resource is only sporadically used as an energy source, main current practice is burning in the field as a low-cost disposal option. Since rubber wood is of relatively high quality (certainly in comparison with other cash crop trees, such as cashew and cocoa), the trunks can form a good basis for timber production. However, this option has so far not been developed in the country, an infrastructure for this type of valorisation is hence not yet available. Other tree residues (branches, smaller stems) as well as sawing residues (should this option be explored) could serve as a feedstock for fuel/pellet production. The use of this residual stream instead of fuel wood (the main thermal energy source) in the rubber production process could provide an opportunity for cost savings and environmental benefits (reducing greenhouse gas emissions and deforestation).

Rubber seeds

Valorisation of rubber seeds through the route of biodiesel (by transesterification of the oil pressed from the seeds) reflects a high potential in terms of added value and greenhouse gas reductions. In addition, it enables the longer-term perspective of servicing higher end markets such as the application of rubber seed oil as a resource material for surface coatings.

Recommendations

- Development of bio-energy applications for tree residues, including for productive use in rubber processing. As a first step, initiate a pilot project comprising the following:
  - Assess market interest among rubber plantations for further exploration of the opportunity - in case of interest:
  - Conduct an inventory of tree residues occurring at the plantation scale: (quality, quantity and continuity of available biomass resources);
  - Assess potential use in the rubber production value chain (e.g. the smoke-drying step for which currently pre-dominantly firewood is used) and necessity of technological adaptations and costs associated with these adaptations.
- Market research into perspectives offered by the valorisation of rubber trees as timber. The plantation level exploration inventory of the previous recommendation could provide input in terms of quality and quantity of trunks. The inventory should include assessing presence of current market actors that could play a role in valorising timber originating from rubber plantations as well as technological and non-technological barriers for the further development of this value chain.
- Development of recovery infrastructure for rubber seeds, to be applied in increasing high value applications from direct fuel to vegetable oil to biodiesel to resource material for green chemistry. The rubber seeds represent a direct market value as well as a fuel feedstock with a considerable CO_2-reduction potential which is currently largely unexploited. This action should be carefully coordinated with the National Agency for Support of Rural Development of Côte d'Ivoire (ANADER) in order to make optimal use of the experience obtained in the pilot project they have recently initiated with Scania and Swedfund.

8.6 Overall conclusions productive use of agricultural by-products in Côte d’Ivoire

There is significant potential for utilising agricultural residues in the cashew, cassava, cocoa, palm oil, and rubber value chains in Côte d’Ivoire in a productive and responsible way.

As one of the fastest growing economies in Africa with a thriving agricultural sector, Côte d’Ivoire produces significant volumes of agricultural by-products on an annual basis. While some of these by-products such as cashew shells, cassava peelings and cocoa bean shells are (to some extent) already utilised efficiently as cattle feed, fertiliser or co-firing feedstock, a considerable amount is left untreated, sometimes causing environmental, human health, and safety risks.

As described in previous sections, technical potential for valorisation of several of the identified biomass streams is evident. Locally available infrastructure, market conditions, and skillsets are to be optimised to ensure the technical potential of these by-products is exploited further.

This study demonstrates opportunities for strengthening local knowledge and sector development, and has identified potential business opportunities for Dutch technology and knowledge providers. A potential obstacle for cooperation identified during the interviews is that the business climate in Côte d'Ivoire is perceived as challenging by Dutch technology providers. This could be addressed by partnering with a trusted local enterprise or company that already has a strong local presence.

8.7 Overall recommendations productive use of agricultural residues Côte d'Ivoire

Strengthening the local sector and knowledge

To strengthen the local sector and knowledge, the following initiatives could be considered:

- Knowledge exchange through university collaboration (see stakeholder map Efor full details);
    - Institut de recherche sur les énergies renouvelables (IREN)
    - Institut National Polytechnique Felix Houphouet-Boigny (INPHB)
    - University Nangui Abrogoua (UNA)
    - Wageningen University and Research (WUR)
- Start-up incubators (for instance for bio charcoal producing companies);
- Business matchmaking.

Opportunities for Dutch involvement

Many of the Dutch technology companies interviewed, mentioned cooperation with a strong local partner is critical for their venturing into Côte d'Ivoire. Existing local infrastructure and investment capital is required to create business opportunities for Dutch technology. To facilitate these collaborations, the following types of initiatives could be considered:

- Market orientation activities;
- Targeted matchmaking;
- Technology and/ or fact-finding missions to Côte d'Ivoire.

The stakeholder map (E) provides an overview of Dutch parties relevant to engage for any follow-up activity.

Limitations and further research

- Cases identified in this study are assessed at high level. Economic, environmental and technical viability are to be further explored and assessed on a case-by-case basis, using site and company specific data.
- As per scope of this study, seven Dutch biomass technology companies were interviewed personally. Follow-up study should broaden engagement with the Dutch biomass technology sector to gauge sector-wide potential and interest for venturing into Côte d'Ivoire.
- Stakeholder interaction during the validation workshop recommended that other value chains are to be explored too, such as rice, mango and cotton.
- Differences in quality and availability of by-products between industrial and small-scale farming could be explored further.

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Annexes

A. Overview table production volumes per region
B. Impact assessment framework
C. Summary proceedings of workshop Abidjan 12 February 2021
D. Production processes per value chain
E. Stakeholder overview
F. Finance Scan
G. Deliverable 1.3: Assessment of biomass potential in Côte d'Ivoire (separate document)
H. Deliverable 1.4: Inventory of energy demand (separate document)

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A. Overview table production volumes per region

Value chain	Oil Palm						Rubber		Cocoa		Cashew				Cassava	
Regions	EFB (tonnes)	Energy potential EFB (TJ)	PKS (tonnes)	Energy potential PKS (TJ)	Mesocarp fibres (tonnes)	Energy potential fibres (GJ)	Rubber seeds (tonnes)	Biodiesel potential (tonnes)	Cocoa pods (tonnes)	Energy potential pods (TJ)	Cashew nut shells (tonnes)	Energy potential shells (TJ)	Cashew apples (tonnes)	Ethanol potential (tonnes)	Cassava peelings (tonnes)	Biogas potential peelings (m^3)
ABIDJAN	23.247	437	5.535	105	13.284	13,3	45.339	9,7	9.100	125	0	0	0	0	18.345	9.118
AGNEBY-TIASSA	4.092	77	974	18	2.339	2,3	46.498	9,9	499.800	6.847	0	0	0	0	31.397	15.605
BAFING	0	0	0	0	0	0,0	0	0,0	0	0	5.632	106	64.360	23.797	6.358	3.160
BAGOUE	0	0	0	0	0	0,0	0	0,0	0	0	39.695	750	453.656	167.739	132	66
BELIER	193	4	46	867	110	110,0	3.055	652,0	80.500	1.103	1.982	38	22.656	8.377	57.909	28.781
BERE	0	0	0	0	0	0,0	0	0,0	1.400	19	81.308	1.537	929.232	343.584	2.814	1.398
BOUNKANI	0	0	0	0	0	0,0	0	0,0	0	0	4.957	94	56.648	20.946	1.749	869
CAVALLY	18	345	4	83	11	11,0	88.096	18,8	1.791.300	24.541	0	0	0	0	8.326	4.138
FOLON	0	0	0	0	0	0,0	0	0,0	0	0	5.079	96	58.040	21.460	230	114
GBEKE	0	0	0	0	0	0,0	15	3,0	700	10	57.124	1.080	652.840	241.388	30.103	14.961
GBOKLE	31.803	598	7.572	143	18.173	18,2	13.439	2,9	1.178.800	16.150	0	0	0	0	6.714	3.337
GOH	1.373	26	327	6	785	785,0	21.984,23	4,7	1.075.200	14.730	0	0	0	0	8.691	4.320
GONTOUGO	0	0	0	0	0	0,0	13.116	2,8	9.100	125	12.230	231	139.776	51.682	17.635	8.765
GRAND-PONTS	49.732	935	11.841	224	28.418	28,4	117.849	25,1	126.700	1.736	0	0	0	0	22.302	11.084
GUEMON	9	173	2	41	5	5,0	6.494	1,4	1.841.700	25.231	377	7	4.312	1.594	5.041	2.505
HAMBOL	0	0	0	0	0	0,0	0	0,0	0	0	51.692	977	590.768	218.436	10.238	5.089
HAUT-SASSANDRA	224	4	53	1	128	128,0	8.753	1,9	1.297.100	17.770	36.870	697	421.376	155.804	18.696	9.292
IFFOU	0	0	0	0	0	0,0	8.344	1,8	13.300	182	1.820	34	20.800	7.691	8.138	4.045
INDENIE-DJUABLIN	210	4	50	944	120	120,0	49.098	10,5	459.200	6.291	1.285	24	14.680	5.428	5.998	2.981
KABADOUGOU	0	0	0	0	0	0,0	0	0,0	0	0	36.961	699	422.408	156.185	4.529	2.251
LOH-DJIBOUA	5.116	96	1.218	23	2.924	2,9	39.467	8,4	1.060.500	14.529	0	0	0	0	14.698	7.305
MARAHOUE	33.078	622	7.876	149	18.902	18,9	21.273	4,5	518.700	7.106	19.541	369	223.320	82.573	51.377	25.535
ME	76	1	18	342	44	44,0	342	73,0	487.200	6.675	0	0	0	0	25.031	12.441
MORONOU	223	4	53	1	128	128,0	1.622	346,0	91.000	1.247	142	3	1.624	600	6.602	3.281
NAWA	0	0	0	0	0	0,0	29.165	6,2	1.354.500	18.557	0	0	0	0	3.227	1.604
N'ZI	0	0	0	0	0	0,0	468	100,0	700	10	634	12	7.248	2.680	8.573	4.261
PORO	0	0	0	0	0	0,0	0	0,0	0	0	36.301	686	414.872	153.399	432	215
SAN-PEDRO	153.931	2.893	36.650	692	87.961	88,0	103.376	22,1	1.820.000	24.934	0	0	0	0	19.213	9.549
SUD-COMOE	147.738	2.777	35.176	664	84.422	84,4	118.405	25,3	264.600	3.625	0	0	0	0	123.970	61.614
TCHOLOGO	0	0	0	0	0	0,0	0	0,0	0	0	7.780	147	88.912	32.875	3.086	1.534
TONKPI	1.449	27	345	7	828	828,0	0	0,0	869.400	11.911	34	1	384	142	42.206	20.977
WORODOUGOU	0	0	0	0	0	0,0	0	0,0	120.400	1.649	42.038	795	480.432	177.640	5.790	2.878
YAMOUSSOUKRO	96	2	23	431	55	55,0	76	16,0	46.900	643	770	15	8.800	3.254	18.171	9.031
Total	**452.609**	**9.024**	**107.764**	**4.740**	**258.634**	**2.470**	**714.288**	**1.346**	**15.017.800**	**205.744**	**444.250**	**8.396**	**5.077.144**	**1.877.274**	**587.723**	**292.104**

B. Impact inventory framework

B.1 Application information/barriers and success factors:

					Barriers/success factors			
Value chain	Residual stream	Current application	Potential application	Potential energy use in vc	Tech. maturity/applicability	Pre-treatment / infrastructure	Connection with ongoing initiative	Other (e.g. regulatory constraints)
Oil palm	Empty Fruit Bunches (EFB)	Plantation fertilizer	After substantial pre-treatment, potential source for pellets	Palm-nut cracking, roasting, oil expression, sifting	Salt content too high for pelletising	pre-treatment required: washing, drying	existing fertiliser application	
	Palm Oil Mill Effluent (POME)	No application currently	Biogas for heat/steam production	Palm-nut cracking, roasting, oil expression, sifting	proven at pilot scale	significant alteration of mill infrastructure required	not in the region	Waste reduction regulations in place (Act 96-766 environmental code)
			Biogas to electricity	Palm kernel crushing, oil expression				
			Biogas to vehicle fuel	FFB transport	pre-pilot stage. Biogas upgrading and vehicle alteration required	biogas upgrading	-	
	Palm Kernel Shells (PKS)	On-site CPO mill steam boiler fuel supplementing fibres.	direct combustion. Trade as co-firing feedstock	Palm-nut cracking, roasting, oil expression, sifting	Suitable boiler fuel for export	easily collected as residue occurs at CPO mill	PKS recognised trade commodityGovernment incentives for coal replacement	Boiler requirements / suitability
	Mesocarp fibres	On-site CPO mill steam boiler fuel	Pellet production* (*scenario pre-condition that CPO mill runs on POME-biogas).	Palm-nut cracking, roasting, oil expression, sifting	Suitable pellet feedstock	start of using POME to power CPO mill is prerequisite		currently used as steam boiler fuel
Rubber	Seeds - crude rubber seed oil (CRSO)	Application currently being explored	Biofuel/biodiesel production	Transport, sheet drying, pressing	proven at pilot scale	collection may be costly	Pilot project ANADER/Swedfund/Scania	n/a
	Tree residues	Some existing examples of steam boiler fuel use.	Direct combustion	Sheet drying, pressing	proven technology	infra to be set-up, drying step required?	as above	n/a
			Pellet production	Sheet drying, pressing	potential of stream to be assessed	infra to be set-up	as above	n/a
Cacao	Bean shells	Some existing examples of steam boiler fuel use.	Direct combustion	Roasting, milling	industrial scale application available	drying step, part of available plant	Various related initiatives, e.g. IDH	n/a
	Pod husks	Some existing examples of bio-charcoal production	Pellet/biochar production	Roasting, milling	Proven at small-scale	Drying step	as above	n/a
	Tree residues	Not utilised currently	Pellet production	Roasting, milling				

Value chain	Residual stream	Current application	Potential application	Potential energy use in vc	Barriers/success factors: Tech. maturity/applicability	Pre-treatment / infrastructure	Connection with ongoing initiative	Other (e.g. regulatory constraints)
Cashew	Cashew Nutshell Liquid (CNSL)	When processed (cardanol) in some cases in chemical industry, local use as fungicide	Biofuel production/biodiesel	Transport	Technology proven, not yet applied in CDI	Pressing, heating of oil to t-CNSL	CBI project, SDGP EcoCajou	n/a
			Biocomposites / resins		Only feasible at large scale? Existing industrial scale application India	as above	Could be explored as follow-up?	Large volume, consistent quality needed - longer term option
	Nut shells	30% of available residue used by factories as fuel	Direct combustion, pellets, biochar	Steaming of seeds, drying of kernels	Low-value application, less efficient than CNSL	Direct application	SDGP EcoCajou?	n/a
	Cashew apples	Largely unused, small-scale local beverage application	Biogas to heat	Steaming of seeds, drying of kernels	Theoretical potential proven,	Fast collection/transport (<24h)	Not in scope of ongoing projects?	n/a
			Biogas to electricity	Sieving, mechanical shelling	as above	as above	as above	n/a
			Bioethanol	Transport	as above	as above	as above	Fuel standards, tax issues
	Film / testa	Animal feed, food supplement	Combustion, biochar	Steaming of seeds, drying of kernels	Experimental stage - research			
	Tree residues		Direct combustion/biochar	Steaming of seeds, drying of kernels				
Cassava	Peeling Residues (CPR)	Partly used as livestock feed	Biogas	Cooking fuel for attiéké, placali	Proven technology	Dispersed availability, limited time window	National project MINEDD started in 2020	n/a
			Bioethanol	Transport	Experimental stage	as above	as above	Fuel standards, tax issues
			Bioplastics		Proven for residues with high starch content, however limited experience with cassave	as above	as above	n/a
	Manioc processing sludge		Biogas	Utilised in starch production	Proven technology at various scales	available at processing plant	as above	permit needed for disposal, incentive for energy application

B.2. High-level sustainability impact inventory

Value chain	Residual stream	Tech. maturity/applicability	Pre-treatment / infrastructure	Connection with ongoing initiative	Other (e.g. regulatory constraints)	Employment	Working conditions	Opportunities for YFE	GHG reduction	Local air quality	Land-use / food-feed competition	Cascading use / circularity	Other	Cost reduction	Profitability	Capex investment required
Oil palm	Empty Fruit Bunches (EFB)	Salt content too high for pelletising	pre-treatment required: washing, drying	existing fertiliser application		limited additonal employment	Value chain risks of labour misconduct to be closely monitored	no direct impact expected	potential through coal replacement/ co-firing.							
	Palm Oil Mill Effluent (POME)	proven at pilot scale	significant alteration of mill infrastructure required	not in the region	Waste reduction regulations in place (Act 96-766 environmental code)	plant operation (skilled staff)	Value chain risks of labour misconduct to be closely monitored	no direct impact expected. potentially in biogas technology value chain	Huge potential through CH4 emission reduction	Huge potential through CH4 emission reduction	Anaerobic digestor can decrease amount of land required for POME ponds	This scenario allows for optimal cascading considering characfteristics of POME and Fibres	more efficient palm oil production limits land expansion and with that community displacement	Potential boiler fuel cost reduction	*this scenario generates additional income from mesocarp fibre pellet production	High upfront investment
						plant operation (skilled staff)	Value chain risks of labour misconduct to be closely monitored	no direct impact expected. potentially in biogas technology value chain					more efficient palm oil production limits land expansion and with that community displacement			
		pre-pilot stage. Biogas upgrading and vehicle alteration required	biogas upgrading	-		Vehicle alteration	Value chain risks of labour misconduct to be closely monitored	no direct impact expected. potentially in PKS trade industry	Through vehicle emissions reduction	Through vehicle emissions reduction	indirect through conventional fuel reduction		more efficient palm oil production limits land expansion and with that community displacement	to be assessed, location specific (depending i.a. on local fuel prices)	to be assessed, location specific (depending i.a. on local fuel prices)	High upfront investment for vehicle alteration/ replacement
	Palm Kernel Shells (PKS)	Suitable boiler fuel for export	easily collected as residue occurs at CPO mill	PKS recognised trade commodityGovernment incentives for coal replacement	Boiler requirements / suitability	Limited for collection as it occurs on-site. Transport/ trade.	Value chain risks of labour misconduct to be closely monitored	limited direct impact expected. Potentially in PKS trade	potential through coal replacement/ co-firing.	no direct impact expected	more efficient palm oil production limits land expansion and with that community displacement	This scenario allows for optimal cascading considering characfteristics of PKS	more efficient palm oil production limits land expansion and with that community displacement	be assessed	additional income through PKS trade	Potential boiler adjustment
	Mesocarp fibres	Suitable pellet feedstock	start of using POME to power CPO mill is prerequisite		currently used as steam boiler fuel	collection, transport	Value chain risks of labour misconduct to be closely monitored	limited direct impact expected. Potentially in pellet trade	Potential through coal replacement/ co-firing. indirect impact through POME utilisation	*Scenario potential through POME application	more efficient palm oil production limits land expansion and with that community displacement	This scenario allows for optimal cascading considering characfteristics of POME and Fibres	more efficient palm oil production limits land expansion and with that community displacement	to be assessed	Additional income through pellet trade	High upfront investment

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Value chain	Residual stream	Barriers/success factors: Tech. maturity/applicability	Pre-treatment / infrastructure	Connection with ongoing initiative	Other (e.g. regulatory constraints)	Social sustainability impact: Employment	Working conditions	Opportunities for YFE	Environmental impact: GHG reduction	Local air quality	Land-use / food-feed competition	Cascading use / circularity	Other	Economic impact: Cost reduction	Profitability	Capex investment required
Rubber	Seeds - crude rubber seed oil (CRSO)	proven at pilot scale	collection may be costly	Pilot project ANADER/Swedfund/Scania	n/a	collection, biofuel value chain	=	yes, setting up new value chain	67 g CO2eq/MJ	reduction pm depending on replacement	avoid fuel wood use	potential for protein / chemical building blocks to be explored	n/a	replacing fossil	competitive price possible	considerable upfront investment
	Tree residues	proven technology	infra to be set-up, drying step required?	as above	n/a	collection of wood residues	=	limited	currently left on land, causing CH4	=	soil fertility	High-quality wood, suitable for timber	n/a	to be assessed	depends on costs of collection	n/a - low - boiler adaptation?
		potential of stream to be assessed	infra to be set-up	as above	n/a	collection, pellet value chain	=	Potential new business development	as above	=	soil fertility	as above	n/a	to be assessed, relatively low volume	depends on costs of collection/pre-treatment	pellet production facility
Cashew	Cashew Nutshell Liquid (CNSL)	Technology proven, not yet applied in CDI	Pressing, heating of oil to t-CNSL	CBI project, SDGP EcoCajou	n/a	biofuel value chain	to be managed - irritating / toxic	involves setting up new value chain	Avoiding fossil (e.g. HFO/FOD), or fuel wood (small-scale)	tba, depends on substitution	=	Potential for composites, green chemistry	currently problematic waste stream	Up to 60-65% cost reduction possible	Most-efficient use in combination with press cake cogen	Depends on application. Installation available at Novarea (requires further investment)
		Only feasible at large scale? Existing industrial scale application India	as above	Could be explored as follow-up?	Large volume, consistent quality needed - longer term option	resin value chain - tbc	as above	as above - tbc	Avoiding non-renewable resources	=	=	Application in chemical industry	as above	more expensive than fossil	specific niche demand for biobased	Investment needed at the side of processor
	Nut shells	Low-value application, less efficient than CNSL	Direct application	SDGP EcoCajou?	n/a	=	=	limited, implementation in existing industry	tba, depends on substitution	tba, depends on substitution	=	low - no potential for material reuse	n/a	replacement of fossil/fuel wood	in case of biochar option/replacement market	very limited investment required
	Cashew apples	Theoretical potential proven,	Fast collection/transport (<24h)	Not in scope of ongoing projects?	n/a	opportunities new set-up of vc	to be managed - irritating / toxic	potential new value chain	currently left on land, causing CH4	reduction pm depending on replacement	soil fertility / potential food-feed competition?	potential wide range applications	n/a	Expected high costs of collection/log	only deemed feasible in combination	investment in medium/large scale digester
		as above	as above	as above	n/a	as above	as above	as above	as above	as above	as above	as above	n/a	as above	as above	as above
		as above	as above	as above	Fuel standards, tax issues	as above	as above	as above	as above	as above	as above	as above	n/a	as above	as above	Considerable
	Film / testa	Experimental stage - research									potential competition food/feed	potential for food additives, pharmaceuticals				

Partners for Innovation

		Barriers/success factors				Social sustainability impact			Environmental impact					Economic impact		
Value chain	Residual stream	Tech. maturity/applicability	Pre-treatment / infrastructure	Connection with ongoing initiative	Other (e.g. regulatory constraints)	Employment	Working conditions	Opportunities for YFE	GHG reduction	Local air quality	Land-use / food-feed competition	Cascading use / circularity	Other	Cost reduction	Profitability	Capex investment required
Cocoa	Bean shells	industrial scale application available	drying step, part of available plant	Various related initiatives, e.g. IDH	n/a	limited employment options after implementation (operation, maintenance)	=	limited, implementation in existing industry	Replacement of fossil (mainly fuel oil)	to be assessed, depends on substitution	Potential competition with food/feed (currently limited); soil fertility	Potential resource material for i.a. food additives	n/a	replacement of fossil	Positively evaluated in comparabe circumstances	Considerable upfront investment
	Pod husks	Proven at small-scale	Drying step	as above	n/a	set-up of small-scale biochar vc	Risk for health issues to be managed	Small-scale new business development	currently left on land, causing CH4	tba, depends on substitution	soil fertility	as above	n/a	Depends on substitution	Several ongoing business initiatives	very limited investment required
	Tree residues										soil fertility					
Cassava	Peeling Residues (CPR)	Proven technology	Dispersed availability, limited time window	National project MINEDD started in 2020	n/a	employment in biogas sector	Potential reduction respiratory issues / pm	biogas sector	Depends on substitution	potential improvement when substituting fuel wood	Potential competition cattle feed		waste stream currently not deemed problematic	reduction of cost/time needed for fuel wood	own (productive) use	investment in digester
		Experimental stage	as above	as above	Fuel standards, tax issues	opportunities new set-up of vc	=		as above		as above					
		Proven for residues with high starch content, however limited experience with cassave	as above	as above	n/a	as above	=	depends on vaibility local value chain	as above		potential competition food/feed	CPR has high starch content		Production costs higher than fossil based - aim for niche market/added value markets for biobased	specific niche demand for biobased	sold as resource material
	Manioc processing sludge	Proven technology at various scales	available at processing plant	as above	permit needed for disposal, incentive for energy application	limited employment options after implementation	=	no direct impact expected. potentially in biogas technology value chain	substitution of fossil LPG	=	Application of digestate for soil improvement	Fertilizer application for digestate?	currently problematic waste stream	Replacing costly LPG	to be assessed, location specific (depending i.a. on waste processing costs)	investment medium/large scale digester

C. Summary proceedings of workshop Abidjan 12 February 2021

Rapport de l’atelier de présentation des résultats partiels de l’étude sur l’évaluation du potentiel de la biomasse par région et l’évaluation du potentiel énergétique

Introduction

Le Vendredi, 12 Février 2021 de 9h 00 à 13h 00, s’est tenu à l’hôtel Ivotel sis à Abidjan Plateau, l’atelier sur l’utilisation productive de la biomasse agricole en bioénergie en Côte d’Ivoire.
(La liste de présence est annexée au présent rapport.)

Cet atelier s’inscrit dans le cadre de l’étude sur l’utilisation productive de la biomasse agricole en bioénergie en Côte d’Ivoire initié par l’Ambassade du Royaume des Pays-Bas en Côte d’Ivoire en vue d’évaluer les possibilités de valorisation énergétique des résidus agricoles et déchets municipaux.
Il a été organisé par le cabinet « Partners for Innovation » en charge de la réalisation de l’étude, en collaboration avec l’Ambassade du royaume des Pays-Bas.
L’objectif assigné à l'atelier était de présenter aux professionnels des domaines de l’agriculture, de la biomasse et de l’énergie, les résultats partiels de l’étude portant sur l’évaluation du potentiel de la biomasse par région et estimation du potentiel énergétique issu de la valorisation de cette biomasse, afin de recueillir leurs avis et suggestions, pour la révision et la validation de ces résultats.
L’atelier s’est déroulé comme suit :

- La cérémonie d’ouverture ;
- La communication 1 relative à la présentation des termes de références de l’étude sur la biomasse en Côte d’Ivoire
- La communication 2 relative à la présentation des résultats partiels
- La discussion et les échanges d’informations sur l’amélioration de la méthodologie de travail des consultants et sur l’acquisition de données récentes relatives à la biomasse en CI

I. CEREMONIE D'OUVERTURE
Le discours d’ouverture a été prononcé par Madame l’Ambassadrice du Royaume des Pays-Bas en Côte d’Ivoire, précédé par un tour de table donnant l’occasion à chaque participant de se présenter et de présenter son secteur d’activité (Nom et structure représentée).
Dans son discours, Madame l’Ambassadrice a souligné que la valorisation de la biomasse contribue non seulement à la gestion écologique des résidus agricoles mais également à la création d’emplois et à l’amélioration des revenus des paysans. Elle a terminé son propos en rappelant aux participants l’objectif de l’atelier avant de déclarer la cérémonie ouverte.

II. COMMUNICATION 1 :
Présentation du cabinet « Partners for Innovation » et des termes de références de l’étude sur la biomasse en Côte d’Ivoire

La présentation du cabinet « Partners for Innovation » et des termes de références de l’étude a été faite successivement par Messieurs Peter VISSERS (Directeur Général de « Partners for innovation ») et Peter KARSCH (membre de l’équipe de « Partners for Innovation »), qui ont participé à l’atelier par vidéo conférence. Elle a consisté à présenter le bureau d’étude (équipe, domaines de compétence et champ d’action) ainsi que le contexte dans lequel se situe le projet sur la biomasse en Côte d’Ivoire.

Dans cette communication, Monsieur Peter VISSERS a indiqué que le cabinet « Partners for Innovation » a conduit en Afrique et Europe plusieurs études portant sur la valorisation énergétique des biomasses et déchets en collaboration avec des experts locaux. A sa suite, Monsieur Peter KARSCH a souligné que les projets de valorisation de la biomasse en Côte d'Ivoire sont réalisables au regard de la densité de la production agricole du pays. Cette communication a également été l'occasion de présenter aux participants les termes de référence de l'étude.

III. COMMUNICATION 2 :
Présentation des résultats partiels de l'étude

Le deuxième point de l'ordre du jour a concerné la présentation des résultats partiels de l'étude. Cette présentation a été faite par Messieurs OUATTARA Koffi Nouho et GUERO Ange Marius, Consultants locaux. Dans son exposé, Monsieur OUATTARA Koffi Nouho a fait un état des lieux de la biomasse en Côte d'Ivoire et a présenté l'approche méthodologique adoptée pour l'évaluation de la biomasse par spéculation. Il ressort de cet exposé que les chaines de valeur cacao, palmier à huile, hévéa, anacarde, manioc ainsi que les déchets municipaux offrent les plus forts potentiels de biomasse valorisable. L'évaluation de la biomasse agricole est essentiellement basée sur l'approche GIZ appliquée au Magreb. Celle approche consiste à appliquer par type de résidu un coefficient à la production totale estimée à partir des surfaces plantées et des rendements à l'hectare. Pour ce qui est des déchets municipaux, la quantité journalière par habitant a été rapportée sur toute l'année à la population par région.
Prenant à sa suite la parole, Monsieur GUERO Ange Marius a présenté les résultats sur le potentiel de biomasse et le potentiel énergétique de cette biomasse. Il a également relevé que pour l'ensemble des spéculations considérées, la production théorique estimée si situe dans la même gamme que la production technique (production réelle). Monsieur GUERO a achevé son exposé en évoquant quelques limites et contraintes de l'étude. Ce dernier a par la suite convié l'ensemble des participants à une pause-café.

A la suite des deux communications, le modérateur de l'atelier a ouvert la séance des discussions et échanges d'informations relatives à la seconde communication. Au cours de ces échanges, les participants ont apporté des amendements sur le contenu du rapport notamment sur l'état des lieux et l'approche méthodologique adoptée pour l'estimation de la biomasse. A ce niveau plusieurs recommandations et préoccupations ont été évoquées.
Monsieur Noel de la structure LONO et Madame NEBOUT Florence du MINADER ont indiqué que les productions théoriques des spéculations considérées dans l'étude étaient surestimées. Concernant le manioc, le coefficient affecté aux épluchures de manioc devrait être fonction de la production de la pâte de manioc et non de l'attiéké. Madame TOURE Yasmina a par ailleurs noté que le conseil café-cacao dispose des données relatives aux productions régionales en Côte d'Ivoire. Elle a donc invité les consultants à contacter les services compétents du conseil café-cacao afin de se procurer ces données. Ensuite Monsieur NIANZOU (Conseil Hévéa Palmier à huile) a souligné la non-existence de certaines structures telles que Palmindustrie et Trituraf mentionnées dans le rapport. Il a suggéré que la liste des acteurs intervenant dans le secteur Biomasse-Energie soit revue et actualisée.
Dans la suite des échanges, le Professeur GBAHA Prospère de l'Institut National Polytechnique Houphouët Boigny (INPHB), a souhaité que dans le rapport de l'étude, la notion de déchets agricoles soit mieux expliquée. Car, au niveau de l'hévéa par exemple, la graine considérée dans cette étude comme un déchet peut être pressée pour produire de l'huile en laissant la place à des fibres. Il a ensuite indiqué que les fleurs sont également valorisables et devraient être prises en compte. Le Professeur GBAHA a par ailleurs souhaité savoir comment la production de biogaz à partir des cabosses vides de cacao et des épluchures de manioc compte se faire. A cela le communicateur

Monsieur GUERO a répondu que l'étude était dans sa première phase. Les questions relatives aux différents procédés de valorisation seront abordées ultérieurement.
Ensuite, Monsieur TRA Bi (Directeur général de SOFCEREC) a voulu savoir si l'étude consistait seulement à une valorisation énergétique de la biomasse ou si elle s'inscrivait dans une logique d'économie circulaire. A cela Monsieur GUERO a répondu que pour l'heure l'étude se focalise principalement sur la valorisation énergétique. Et cette valorisation ne prend en compte que les principales spéculations à forte production notamment le palmier à huile, l'hévéa, le cacao, l'anacarde, le manioc et les déchets municipaux. Monsieur TRA Bi a ensuite suggéré la prise en compte des chaines de valeur telles que le riz, le coton et la mangue qui ont un potentiel non négligeable. Soutenu par Monsieur CISSE, il a par ailleurs indiqué que pour l'évaluation de la biomasse issue de la chaine de valeur cacao, Il faudra tenir compte des superficies occupées par les différentes variétés de cacao produites en Côte d'Ivoire. D'autant plus que le cacao Mercedes produit 2 à 4 plus que le cacao tout venant (cacao ancien). A cela Madame TOURE Yasmina a ajouté que les réalités concernant les surfaces plantées ont beaucoup évoluées ces dernières années du fait du changement climatique. Ainsi, la boucle du cacao qui se trouvait en 2016 au niveau de la région de la Marahoué, a aujourd'hui migré vers l'ouest du pays. Il faudrait alors en tenir compte dans l'évaluation de la biomasse. Les communicateurs ont dit prendre bien note de ces pertinentes observations qui contribueront à parfaire la méthode d'évaluation de la biomasse.
Enfin, Monsieur TRA Bi a au regard de son expérience évoqué certaines contraintes liées à la règlementation relative aux énergies renouvelables en Côte d'Ivoire et a par conséquent proposé que le projet soit orienté vers une approche « économie circulaire ».

Monsieur KOUAME de l'Ambassade du Royaume des Pays-Bas, relativement aux contraintes soulevées par Monsieur TRA Bi a assuré que les initiateurs du projet entendent rencontrer l'Etat pour engager des discussions sur la question.

3- Divers
Au chapitre des divers, le Consultant local Monsieur GUERO, a tenu à informer les participants que des échéances et visites sont prévues dans le cadre des activités de ce projet. Il a aussi indiqué qu'une copie du rapport final sera envoyée à chaque participant pour appréciation.

Fin de la réunion
M. Kouame a remercié les participants pour leurs contributions et a indiqué que de nouveaux résultats seront obtenus au cours des prochains mois. Il a également souligné le suivi de l'étude, qui pourrait inclure un échange entre la Côte d'Ivoire et les Pays-Bas sur le thème de la biomasse.
Les travaux du présent atelier sur la biomasse en Côte d'Ivoire ont pris fin à 13h 00, avec les mots de remerciement de Monsieur GUERO à l'endroit des participants pour leur participation effective à cette importante réunion.

Le rapporteur
Dr TAPE Logboh David

D. Production processes per value chain

Cashew

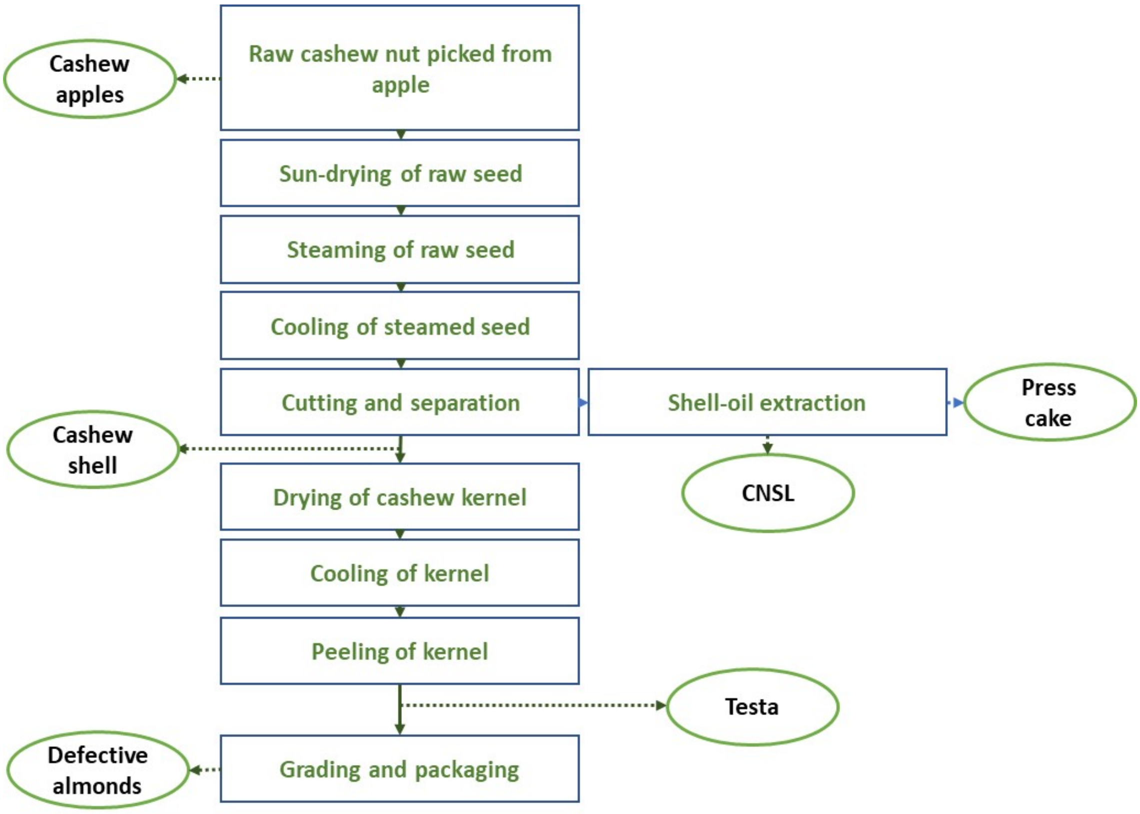

Figure 16 Flow chart of cashew nut processing in small processing plants (based on FDI, 2020)

Cassava

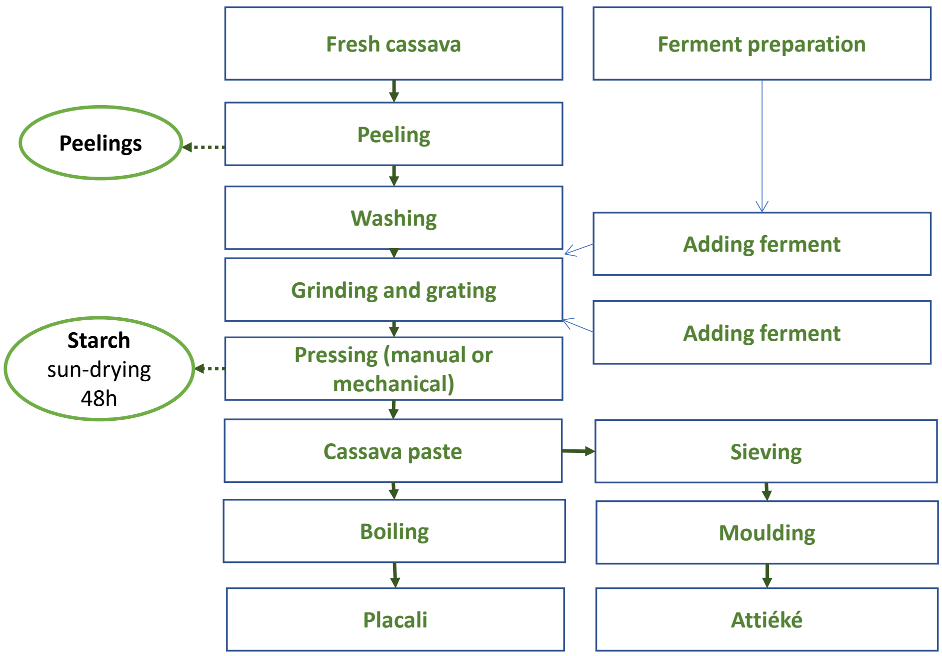

Figure 17 Overview of production process of Placali and Attiéké

Cocoa

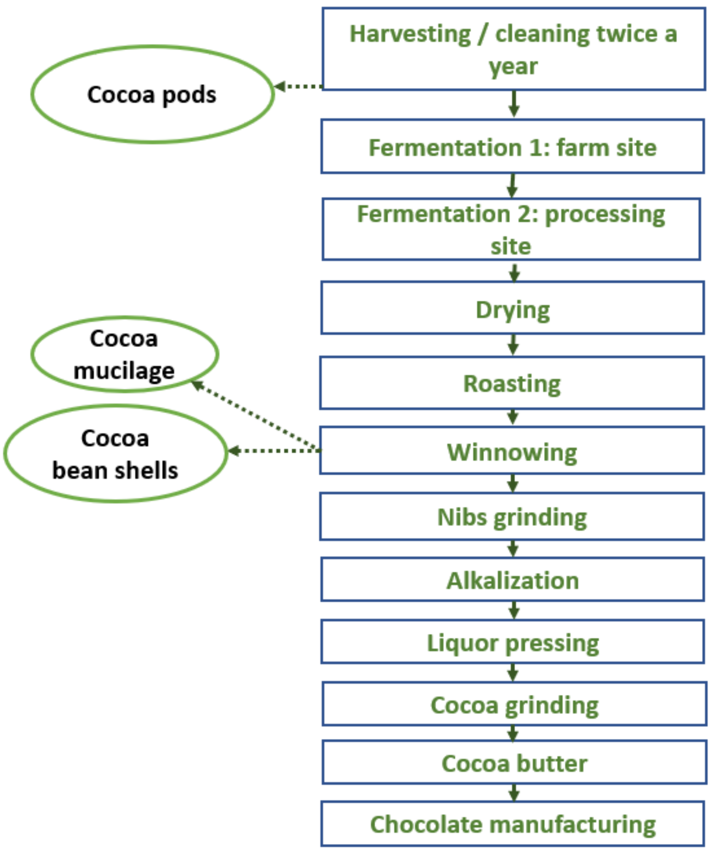

Figure 18 Overview of production process of cocoa (adapted from ICCO)

Palm oil

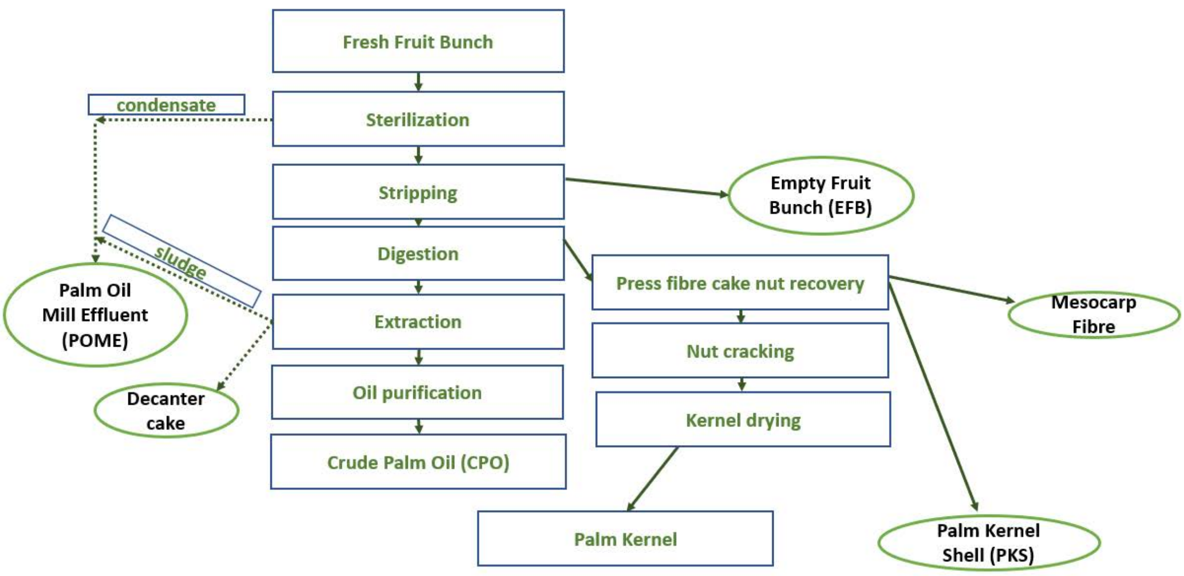

Figure 19 Overview of production process CPO mill (adapted from FAO)

Rubber

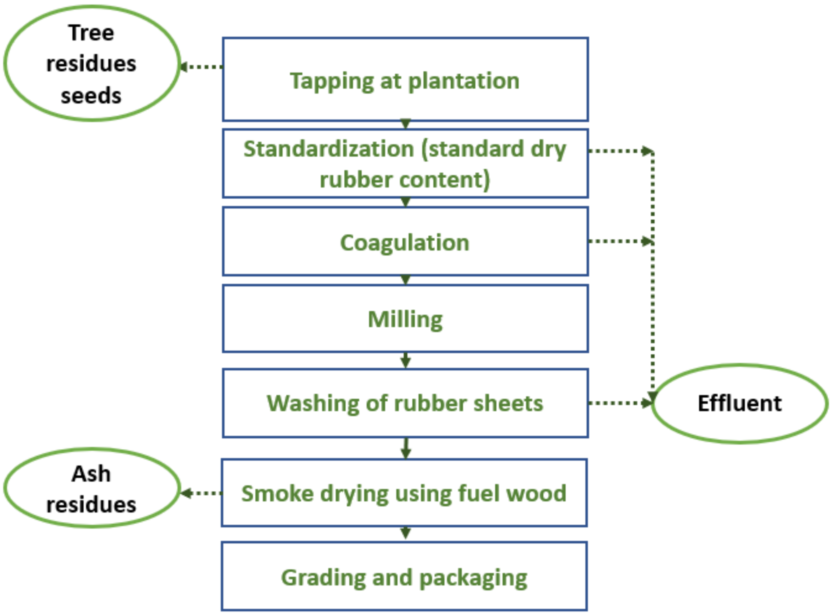

Figure 20 Overview of rubber production process

E. Stakeholder map

The Netherlands

Company name	Category
Adverio BV	Bioenergy technology company
African Clean Energy (ACE)	Bioenergy technology company
Away4Africa	Agriculture - cashew value chain
Biogas Plus	Bioenergy technology company
BiogasJG	Bioenergy technology company
Biosys	Bioenergy technology company
Blackwood Technology	Bioenergy technology company
Bright Biomethane	Bioenergy technology company
BTG Biomass Technology Group	Bioenergy technology company
CBI	Government body/ ministry
Clean Electricity Generation B.V. (CEG)	Bioenergy technology company
CocoaNect	Agriculture - cocoa trade
Colsen	Bioenergy technology company
Colubris Cleantech	Bioenergy technology company
CPM Europe	Equipment provider
DADTCO - PhilAfrica Manioc CI	Agriculture - cassava processor
Dahlman Renewable Technology	Bioenergy technology company
DMT Environmental Technology	Bioenergy technology company
Dutch Charcoal Furnaces/ Refratec	Bioenergy technology company
Econvert Water & Energy	Bioenergy technology company
Energy Transformers	Bioenergy technology company
Enki Energy	Bioenergy technology company
European Biogas Association	Industry Association
European Commission	International body
Fairmatch Support	Consultancy
FAO	International body
Finco Fuel Group	Bioenergy technology company
Futerra Fuels	Bioenergy production company
Holland Biomass	Bioenergy technology company
Hortifresh consortium	Development programme
Host	Bioenergy technology company
IDH	NGO
Ingenia Consultants & Engineers BV	Consultancy
IQS4	Consultancy
KARA Energy Systems	Bioenergy technology company
Ministry Agriculture, Nature and Food Quality	Government body/ ministry
Ministry of Economic Affairs and Climate	Government body/ ministry
Ministry of Foreign Affairs	Government body/ ministry
NABC	Networking organisation
Netherlands Enterprise Agency	Government body/ ministry
NVDB - Nederlandse Vereniging voor Duurzame	Industry Association
Paques	Bioenergy technology company
Platform Bio-Economie	Industry Association
Platform Duurzame Biobrandstoffen	Industry Association
Solidaridad	NGO

SNV	NGO
Stork Thermeq	Equipment provider
TechForce	Consultancy
TNO/ ECN	Semi-government company
Torrcoal	Bioenergy technology company
Torrgas	Bioenergy technology company
Torwash	Bioenergy technology company
Wageningen University & Research	University/ Knowledge institute
Witteveen + Bos	Consultancy
Yilkins Netherlands	Bioenergy technology company

Côte d'Ivoire

Company name	Category
ADAM AFRIQUE	Secteur Privé
AFD - Agence Française de Développement	Institution multi-latérales
AITS (Scierie à San -Pédro)	Secteur Privé
AIZ conseil	Secteur Privé
ANADER	Structure gouvernementale
ANAGED	Structure gouvernementale
ANARE CI	Structure gouvernementale
ANDE	Structure gouvernementale
APROMAC	Structure gouvernementale
Banque Mondiale	Institution multi-latérales
CBI	Organisation de la société civil
CEPICI	Structure gouvernementale
CI Energies, Côte d'Ivoire Energies	Structure gouvernementale
CONSEIL CAFE - CACAO	Structure gouvernementale
CONSEIL COTON- ANARCADE	Structure gouvernementale
CONSEIL HEVEA-PALMIER A HUILE	Structure gouvernementale
DSO (San-Pédro)	Secteur Privé
EDF - CI	Secteur Privé
EU	Institution multi-latérales
FEXIM (San-Pédro)	Secteur Privé
FINERGREEN	Secteur Privé
FIRCA	Structure gouvernementale
FOANI	Secteur Privé
GIZ	Institution multi-latérales
Groupe SIFCA-BIOKALA	Secteur Privé
Groupe SIFCA-PALMCI	Secteur Privé
Groupe SIFCA-SANIA	Secteur Privé
Groupe SIFCA-SAPH	Secteur Privé
Groupe SIFCA-SUCRIVOIRE	Secteur Privé
Holding Groupe EOULEE SA	Secteur Privé
IDH	Organisation de la société civil
INP-FHB (Laboratoire Biomasse-Energie; Institut de	Institution academique et de recherche
IVOBOIS ou ETABLISSEMENT NOURA (San-Pédro)	Secteur Privé
KfW	Institution multi-latérales
LONO	Secteur Privé
MINISTÈRE DE L'AGRICULTURE ET DU DÉVELOPPEMENT	Ministère (elaboration des politiques)

MINISTÈRE DE L'ENVIRONNEMENT ET DU DEVELOPEMENT DURABLE	Ministère (elaboration des politiques)
MINISTÈRE DE L'ASSAINISSEMENT ET DE LA SALUBRITÉ	Ministère (elaboration des politiques)
MINISTERE DES EAUX ET FORETS	Ministère (elaboration des politiques)
MINISTERE DES RESSOURCES ANIMALES ET HALIEUTIQUE	Ministère (elaboration des politiques)
MINISTERE DU COMMERCE , DE L'INDUSTRIE ET DE LA PROMOTION DES PME	Ministère (elaboration des politiques)
MINISTERE DU PETROLE, DE L'ENERGIE ET DES ENERGIES RENOUVELABLES / - La Direction des energies nouvelles et Renouvelables	Ministère (elaboration des politiques)
MOKANTI SARL	Secteur Privé
Nitidæ	Organisation de la société civil
OBB (scierie à San-pedro)	Secteur Privé
OLAM	Secteur Privé
ONAD	Structure gouvernementale
ONG Chigata	Organisation de la société civil
PALMAFRIQUE	Secteur Privé
SIPRA	Secteur Privé
Société coopérative agropastorale Tiéporigo de Boundiali (CATB COOP-CA)	Secteur Privé
Société Coopérative caoutchou naturel du SUD (SCNS) à Aboisso	Secteur Privé
Société coopérative COASI de Sinikosson (Méagui)	Secteur Privé
Société coopérative des eco-agriculteurs modernes de Méagui (ECAMOM COOP-CA)	Secteur Privé
Société coopérative des hevéaculteurs modernes du cavally (HEMOCA-COOP-CA) à Guiglo	Secteur Privé
Société coopérative des planteurs de BLIDOUBA (COOPABLI COOP-CA)	Secteur Privé
Société coopérative des planteurs de palmier à huile des associe de mafere (COOPHARM COOP-CA)	Secteur Privé
Société coopérative des producteurs d'anacarde, de coton, et de vivriers de Boundiali (COOP-CA)	Secteur Privé
SODEFOR	Structure gouvernementale
SODEN, Société des énergies nouvelles de Côte d'Ivoire	Secteur Privé
SOFCEREQ	Secteur Privé
SOGB, Société de Caoutchouc de Grand Béréby (Socfin)	Secteur Privé
SOLIDARIDAD	Organisation de la société civil
SUCAF CI	Secteur Privé
Université NANGUI ABROGOUA (IREN)	Institution academique et de recherche
USTDA, Agence américaine pour le commerce et le développement	Institution multi-latérales

F. Finance Scan

This section provides an overview of relevant Dutch finance instruments and tools for innovative programmes and businesses in the renewable energy/biomass sector available in Côte d'Ivoire.

For information please reach out to the Dutch embassy and/or RVO.

Two main categories:

A. Subsidies

Impact cluster

a. 3-4 year instrument for companies to test their business case with 50% subsidy
b. Similar to PIB (See below) for challenging markets
c. Existing cluster in CdI for Horticulture
d. More info – through embassy and RVO

SDGP – Sustainable Development Goal Partnerships (temporarily closed)

a. Public-private partnership (PPP) approach including technical assistance
b. More info: https://english.rvo.nl/subsidies-programmes/sdgp

DHI Subsidy scheme

a. The demonstration projects, feasibility studies and investment preparation studies (DHI) is a subsidy for SMEs with international ambitions in emerging markets and developing countries. The DHI programme helps SMEs test the feasibility of their concepts abroad, so that more Dutch companies can successfully contribute to sustainable development in these regions.
b. More info: https://english.rvo.nl/subsidies-programmes/dhi

Land at scale

a. LAND-at-scale is a land governance support programme for developing countries. A large part of the world's population depends on having secure access to land for their incomes. LAND-at-scale aims to contribute to fair and just tenure security, access to land and natural resources for all. This will lead to more sustainable and efficient use of land and natural resources for food, housing and production. It will also reduce conflicts and competing claims over land.
b. More info: https://english.rvo.nl/subsidies-programmes/land-at-scale

B. Instruments/ Assignments:

FVO Partnerships

a. FVO supports Dutch partnerships that wish to:
   - conduct local or regional research into the underlying causes of RBC risks and misconduct in their value chains and implement measures to address them;
   - implement RBC into their business processes in a more effective manner, including measures to end RBC risks and misconduct in their own company;
   - set up a multi-stakeholder project that addresses RBC risks and misconduct, with a positive impact on manufacturing conditions in their producer countries.
b. More info: https://english.rvo.nl/subsidies-programmes/fvo-partnerships-pillar-1

Partners for International Business

a. Partners for International Business (PIB) is a programme that allows Dutch businesses to enter into a public-private partnership to realise their international ambitions. Doing business abroad is not always easy. You may be confronted with trade barriers, a lack of knowledge among local government bodies and businesses or restrictive local laws. Joining forces with other businesses in your industry and with the Dutch government puts you in a better position.
b. More info: https://english.rvo.nl/subsidies-programmes/partners-international-business-pib

Starters for international Business

a. Promoting businesses and projects abroad
b. More info: https://www.rvo.nl/subsidies-regelingen/starters-international-business-sib

Development Related Infrastructure Investment Vehicle – DRIVE

a. Financing for companies in low and middle income countries that want to improve the infrastructure and thus stimulate the local business climate.
b. More info: https://english.rvo.nl/subsidies-programmes/development-related-infrastructure-investment-vehicle-drive

Young Expert Programmes Energy – YEP Energy

a. Subsidy for companies active in the field of renewable energy in developing countries to employ a young professional.
b. More info: https://english.rvo.nl/young-expert-programmes-energy-yep-energy

Dutch Good Growth Fund – DGGF

a. For Dutch entrepreneurs interested in emerging markets or developing countries? Then you may be eligible for the Dutch Good Growth Fund (DGGF).
    i. Triple jump: local SME's
    ii. Atradius: export guaranties
    iii. Technical assistance
b. More info: https://english.rvo.nl/subsidies-programmes/dutch-good-growth-fund-dggf

Orange Corners Innovation Fund – OCIF

a. Orange Corners Innovation Fund (OCIF) provides fund managers with capital to invest in early-stage start-ups in OCIF target locations.
b. More info: https://english.rvo.nl/subsidies-programmes/orange-corners-innovation-fund-ocif

Dutch Visitors Programme

a. Has already taken place – incoming mission from Côte d'Ivoire
b. More info: https://english.rvo.nl/information/incoming-visitors-programmes/high-potentials

Additional relevant private sector development partners

FMO

a. Dutch development Bank
b. More info: https://www.fmo.nl/about-fmo

2 Scale Programme

a. 2SCALE offers a range of support services to private partners – companies and farmer groups – enabling them to produce, transform and supply quality food products to local, national and regional end-user markets, including Base of the Pyramid consumers.
b. More info: https://www.2scale.org/

Dutch Employers' Cooperation Programme (DECP)

a. Dutch Employers' Cooperation Programme (DECP) focuses on strengthening employers' organisations in emerging countries with the aim of contributing to the improvement of the business climate.
b. More info: https://www.decp.nl/

PUM

PUM's provides entrepreneurs with advice for the sustainable development of their business. PUM experts are all volunteers who provide clients with practical advice and support them in applying it. Experts and clients work together, for as long as it takes until the client has enough knowledge to continue on their own.
More info: https://www.pum.nl/en/what-we-do

G. Deliverable 1.3: Assessment of biomass potential in Côte d’Ivoire (separate report)

H. Deliverable 1.4: Inventory of energy demand (separate report)

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