# Environmental Study of Waste Management

# in Cashew Processing

# in eight African countries

*Benin, Burkina Faso, Côte d'Ivoire, Ghana,*
*Guinea-Bissau, Kenya, Mozambique, Tanzania*

Prepared by

Away4Africa

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This report of the Environmental study on the cashew by-products in 8 African countries is a result of a consulting and analytic process. The study is commissioned by and under the responsibility of the African Cashew Alliance (ACA). The study is conducted by Away4Africa, a company based in the Netherlands, in association with Fúnteni Installations et Conseil, a company based in Burkina Faso.
We thank the ACA for the trust and collaboration that we experienced throughout the process. We felt encouraged responsibilities and trust that was given.
We are also thankful to the actors in the field, particularly the processors, who allocated time and shared information and ideas. We felt an interest on nearly all levels to scope more about the potential of by-products.
We hope that this report contributes to precise the current and potential of the cashew by-products and that it would be a starting point to enlarge the scope for common strategy, partnership, investments and finally economic, energetic and environmental impact.

October, 2018



Wim Simonse, Away4Africa
Julia Artigas, Fúnteni Installations et Conseil

# ACRONYMS

| | |
|---|---|
| ABE | Agence Béninoise pour l'Environnement |
| ACA | African Cashew Alliance |
| ACPG | Association of Cashew Processors Ghana |
| AICAJU | Mozambican cashew processing association |
| ANDE | Agence Nationale de Développement de l'Environnement |
| ANTA | Association Nationale de Transformateurs de l'Anacarde |
| BUSAC | Business Sector Advocacy Challenge |
| CAIA | Célula de Avaliação do Impacto ambiental |
| CBT | Cashew nut Board of Tanzania |
| CCA | Conseil du Coton et de l'Anacarde |
| CDM | Clean Development Mechanism |
| CER | Certified Emission Reductions |
| CHP | Combined Heat and Power |
| CIAB | Comité de l'Interprofession |
| CIAPOL | Centre Ivoirien Antipollution |
| CICC | Consultative International Cashew Council |
| CIESA | International Colloquium for Scientific Exchange on Cashew |
| CNSL | Cashew Nut Shell Liquid |
| CNTC | National Council of Cashew Processors |
| CPDN | Contributions prévues déterminées au niveau national |
| DDO | Distillate Diesel Oil |
| EPA | Environmental Protection Act |
| EPA | Environmental Protection Agency |
| EW | Ex Works |
| FENAPAB | Fédération Nationale des Producteurs d'Anacarde du Bénin |
| GEF | Global Environment Facility |
| GHG | Green House Gases |
| GIC-CI | Groupement Industriel de Cajou de la Côte d'Ivoire |
| H2CP | High Calorific Cashew Pyrolyser |
| IFA | Interprofession de la Filière Anacarde |
| INCAJU | Instituto de Fomento do Cajú |
| INDC | Intended Nationally Determined Contributions |
| IPCC | Intergovernmental Panel on Climate Change |
| KPI | Key Performance Indicator |
| LHV | Lower Heating Value |
| MCC | Millennium Challenge Corporation |
| Mt | Metric ton (=1,000 kg) |
| NCCAP | National Climate Change Action Plan |
| NCPCG | Ghana National Production Center |
| NEMA | National Environment Management Authority |
| NEMC | National Environmental Management Council |

| | |
|---|---|
| NutPAK | Nut Processors Association of Kenya |
| PCB | Pollution Control Board |
| R&D | Research and Development |
| RCN | Raw Cashew Nuts |
| SDG | Sustainable Development Goals |
| SME | Small and Medium Entreprise |
| T-CNSL | Technical Cashew Nut Shell Liquid (CNSL after decarboxylation) |
| tCO2eq | ton carbon dioxide equivalent |
| UNCEA | Union Nationale des Commerçants et Exportateurs de l’Anacarde |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UNPA | Union Nationale des Producteurs d’Anacarde |
| VER | Verified Emission Reductions |

# EXECUTIVE SUMMARY

The report presents the current and potential features of the cashew by-products in 8 African countries (Benin, Burkina Faso, Côte d'Ivoire, Ghana, Guinea-Bissau, Kenya, Mozambique, Tanzania). The assessment includes (i) the environmental adverse effects that cashew processing might potentially cause to the environment, (ii) the current waste management practices and business approaches of cashew processors in selected countries in East and West Africa, and reveal shortcomings and harmful environmental practices deployed in their daily routines, and the best practices and environmental standards from Africa and Asia that reduce and bring an end to harmful waste management practices, (iii) the unexploited economic, energetic and environmental potential and (iv) the analysis of the stakeholders involved in cashew by-products.

As ***key findings*** of the study, in the first place it is observed that the cashew processing still faces the issue of **weak competitiveness**. The main concerns of processors are focused on the RCN supply: price stability, export bans and regulations, quality and finance. Globally, over the 8 countries visited, the priority given that the value addition of the by-products is not high. Although, the shells accounting for 70% of the RCN biomass, this waste is deposited or removed, but **value addition is hardly practiced**. Nearly all factories use the shells **for thermal energy**, most as fuel for the boiler. The consumption of shells for thermal energy varies from 5-25% of the shells produced. Nevertheless, the overall **most-efficient strategy** for value addition of by-products is the processing of CNSL and co-generation of the de-oiled cake. The condition is a secured supply of minimum 15,000-20,000 Mt shells per year, allowing co-generation capacity of 1.5 MWe. There is an unexploited **potential** of cashew by-products. With the total RCN production of nearly 1.4 million Mt RCN and given the average of 10% processed RCN in the countries: out of a total potential quantity of nearly 1 million Mt of shells/yr, currently a quantity of about 100,000 Mt is of shells is produced in these countries: about 25% is is used for value addition (50% of CNSL production and the rest for thermal energy purposes). There is an unexploited potential of US$16m, or US$110 /Mt RCN of turnover that is not exploited in the current situation. The processing of the cashew shells can contribute to a positive energy balance that varies from 211,081 MWh to 1,975 GWh. The processing of the cashew shells can contribute to a positive carbon balance that varies from 58,560 to 548,135 tCO2eq. Moreover, **small scale initiatives** and solutions (production of charcoal through carbonization of shells, power generation with steam machines) are found here and there, but the viability and sustainability is not really confirmed, as most of these initiatives are in the R&D phase and depend on subsidies. More experience on testing and scaling up of this equipment would be required to confirm the business case. Concerning policies and the institutional setting, we observe a potential leading role in promotion of by-products through these institutional sector organizations. **Environmental legislation frameworks** are well established and institutionally embedded. Some countries are more advanced. Work can be done on standardization and professionalization of the environmental standards, procedures and control measures. Policy **regulations on electricity production** and supply are not in all countries well established. Particularly in West African countries, this vacuum constitutes a risk for the business case on co-generation.

Specific ***opportunities*** that were found and confirmed during this study were the local use for CNSL as a **substitute for DDO/LFO,** seems to be more profitable than for export. The opportunity for energy production from biomass constitutes an increasing opportunity to supply the energy deficit with green energy. Substitution of conventional energy by green energy (either electrical, or thermic) contributes to the **reduction of carbon emissions**. Most of the countries have included the value addition of biomass and production of green energy in their National Development policies. Value addition of the cashew by-products through green energy contributes to the Intended Nationally Determined Contributions. Currently, there are **hardly any incentives** for investments on green energy from biomass and specifically applied to the cashew by-products in the African countries, including uses of biomass for thermal purposes. Although the CDM and MCC might be convenient financing mechanisms for green investments and carbon offset.

***Recommendations*** are made towards **governments and the para-public sector**: (i) first, **secure supply of shells** for viable CNSL production and co-generation, (ii) enhance **applied research** on the adaptation of technologies for the cashew by-products and alternative (local) applications of the derivates. (iii) facilitate spreading the **existing knowledge by exchange** on by-product practices, (iv) improve **investment climate** for waste recycling (v) enable the **CDM financing instruments** for the biomass-to-energy projects (vi) develop a **coherent vision and strategy** on cashew by-products on national level and (vi) link the carbon emission reduction, due to the value addition of the cashew by-products to the **Intended Nationally Determined Contributions**.

For the **sector organizations** on national (and regional) level: (i) facilitate **exposure** to and **exchange** on the technologies for processors and governmental bodies and stimulate interactions (ii) **provide an assessment** of the energy and carbon emission reduction at national and even regional level, (iii) **reform** of the national cashew sector agencies so that support to processors becomes a priority, and the focus on by-products is given as means to secure financial stability for them, (iv) **advocate for an extension of these measures to the by-products.**

For the **private sector actors**: (i) **explore** the different available solutions for by product development, (ii) be **compliant** with the environmental standards, (iii) conduct further the **assessment** of the opportunity of energy from by-products (iv) start **collaboration** between processors to create scale and a regular supply of shells for operation that require larger quantities: CSNL extraction and co-generation. Common investments or third-parties can be a next step. Private-public partnership seems to be a convenient setting for by-product investments, as the outcomes benefit private and public interest and (v) finally, realize the **investments** in by-product processing capacity, including the technical competence of staff.

For the **African Cashew Alliance**: ACA's position should be that of **catalyzing change**, by raising awareness and giving echo to all the ongoing by-product initiatives – and seeking for replication and opportunities: (i) assist **the factories to abide** by the national regulations, because lack of observance can become a big issue in the future, (ii) develop a specific cashew by-product **policy** with the necessary instruments and facilitation of incentives for the ACA members, (iii) support the countries' **sector associations/agencies** to improve their organizational abilities and strengthening the processors representatives. One idea would be having one ACA representative in each country, (iv) develop **documentation on environmental impact reduction** methods, addressed to processors and environmental authorities and (v) integrate the assessment of energy from biomass and carbon emission (reduction) into the assessment criteria of the **ACA seal**.

The overall conclusion is that there is a unexploited potential by valorizing of the cashew by-products, particularly of the shell, for the manufacturing industry and thermal energy, while contributing to the energy production and climate carbon offset.

# CONTENTS

# 1 Introduction

## 1.1 Background

Within the frame of the policy of the African Cashew Alliance (ACA) and the project 'Support for African Cashew Industries (East and West Africa)', the 2nd component embraced the Environmental management and sustainable processing. The first part is a feasibility study on environmental and waste management in cashew processing and recommend/develop mitigation measures and best practices for improvement. This task has been assigned to Away4Africa, in collaboration with Fúnteni Installations et Conseil. Regarding the second part, the Training to cashew processing stakeholders on improved environmental waste management practices, the study includes a couple recommendations to the ACA for this training. For this study, 8 African countries were selected: Benin, Burkina Faso, Côte d'Ivoire, Ghana, Guinea-Bissau, Kenya, Mozambique and Tanzania. Therefore, the focus in this report will be on these countries.

## 1.2 Purpose and activities

The purpose of this study is to assist the factories in their bid to improve efficiency and processing and food safety standards which are also key focus areas of the project.
The activities under this study are:
i. Evaluate environmental adverse effects that cashew processing might potentially cause to the environment.
ii. Identify the current waste management practices and business approaches of cashew processors in selected countries in East and West Africa, and reveal shortcomings and harmful environmental practices deployed in their daily routines.
iii. Highlight and assess best practices and environmental standards from Africa and Asia that reduce and bring an end to harmful waste management practices.
Once executed, this analysis will help to determine a course of action that will be promoted to prevent and mitigate environmental risks arising from cashew processing all over Africa.

Focus points in the study:
Precisely on cashew processing, the focus will be on the beneficial and adverse environmental effects:

*Table 1. Waste practices and their beneficial and adverse effects*

| Practice | Beneficial effects | Adverse effects |
|---|---|---|
| Use of shells as combustible in steam boilers of the processing unit | Replacement of wood as combustible -> saving energy and environment | Incomplete combustion -> air pollution and soot on equipment |
| Disposal of shells at the factory site and surroundings | - | Decay of shells -> pollution of soil and surface water<br>Risk of fire -> air pollution<br>Opportunity cost on by-products |
| Steaming RCN before deshelling | Cleaner than roasting process | Waste water -> pollution of soil and surface water |
| Heating and decarboxylation of CNSL | T-CNSL production creates value from bio waste | Air pollution, in case when combustion is done with shells |

| | | |
|---|---|---|
| Disposal or open air burning of testa | | Opportunity cost on by-products |
| Storage of rotten kernels / disposal near the factory | | Attracts pests, may affect main product<br>Opportunity cost on by-products |
| Use of cashew shells (or de-oiled shells) for electricity generation, charcoal | Substitution of (electrical) energy based on conventional biomass | |
| Potential carbon emission reduction by generation of green energy | Positive contribution to the carbon balance of the factory, the sector and on national level | |

Then, other institutions linked to cashew processors will be identified and interviewed. Institutions reviewed are Cashew processors' representative bodies – whether public or private -, Ministries and public agencies dealing with the environmental impacts of above mentioned activities, and other entities working to support the cashew industry, like Development agencies. The aim is to identify strengths and weaknesses in the mutual relationships between processors and institutions.

## 1.3 Approach and responsiveness

Factories, sector associations, policy makers and public institutions were consulted on the cashew by-product potentials and constraints.

In general, we found a keen interest on the issue, particularly from the factories.

There were in total 131 organizations identified in the 8 countries with responsibilities in the cashew sector and mostly all related to by-products. Next, we had contact with Asian (Indian and Vietnamese) organizations. In total, 111 organizations (90%) were contacted. In countries with numerous processors, not all were contacted. A response of 85% (84/111) on the surveys was obtained and were visited. Among the 84 organizations surveyed, 59 are factories, of which 51 were visited and/or interviewed (86%).

The attitude of the organizations was open and they were interested. The surveys were interactive and brought up new insights for both parties. From our side, in each interview, we brought in information on solutions, technologies and figures on the by-products and interactions were made on the suitability of the solutions.

*Table 2. Responsiveness of actors in the cashew sector in the 8 countries*

| Country | Organizations identified | Organizations contacted | Organizations contacted and interviewed | Processors interviewed | Factories visited |
|---|---|---|---|---|---|
| Benin | 8 | 8 | 7 | 4 | 4 |
| Burkina Faso | 7 | 7 | 7 | 4 | 4 |
| Côte d'Ivoire | 43 | 28 | 17 | 15 | 12 |
| Ghana | 12 | 11 | 8 | 2 | 2 |
| Guinea-Bissau | 13 | 11 | 11 | 4 | 4 |
| Kenya | 6 | 6 | 6 | 5 | 5 |
| Mozambique | 27 | 25 | 21 | 15 | 13 |
| Tanzania | 15 | 15 | 7 | 10 | 7 |
| **Total** | **131** | **111** | **84** | **59** | **51** |

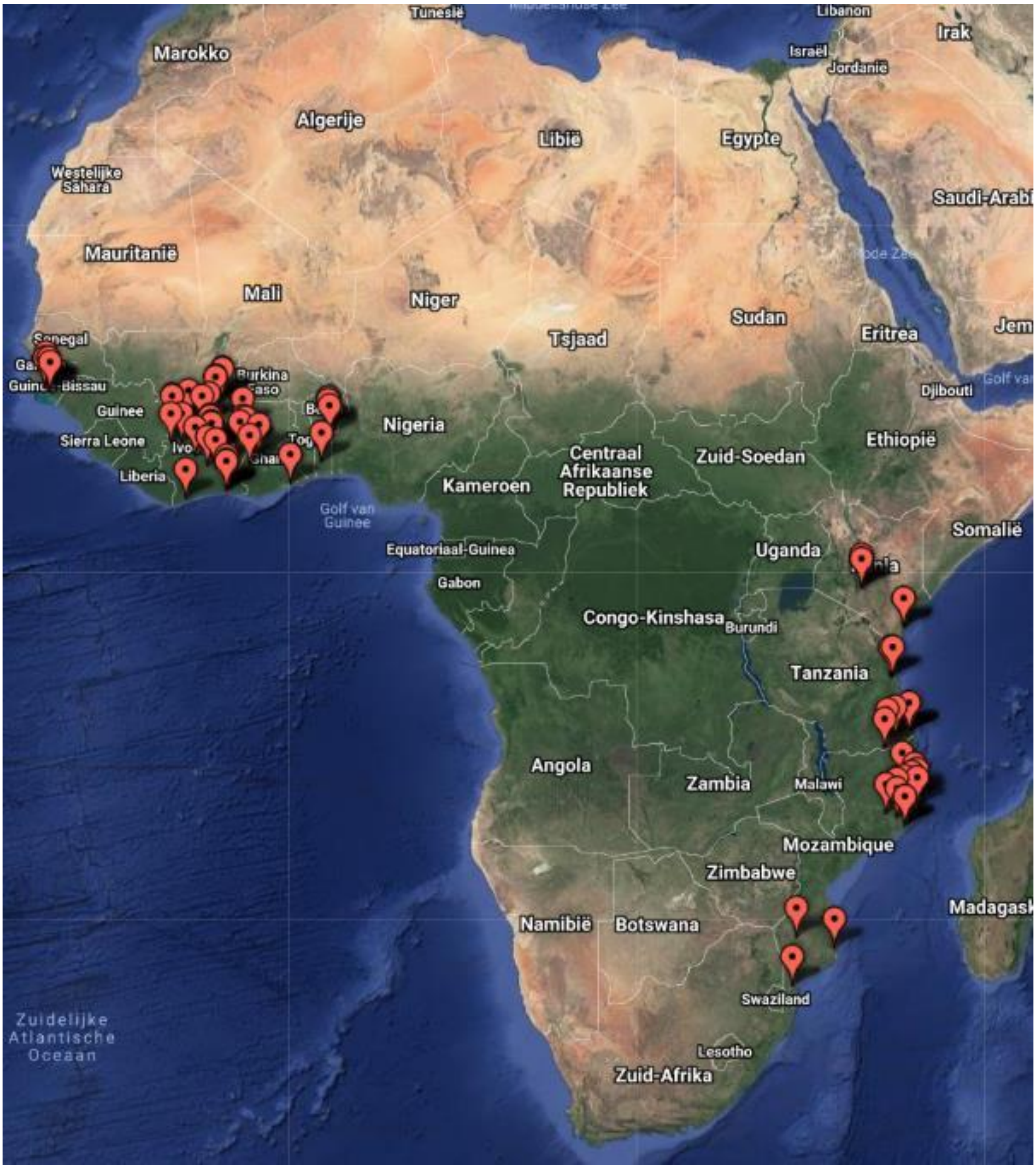


*Figure 1. Geographical position of the cashew processing factories in the 8 countries (Source: collected data during field visits Away4Africa, Fúnteni Installations et Conseil)*

The proposed solutions are summarized in this report. More elaborate technical information on the technical and economic feasibility of the solutions can be provided by Away4Africa and Fúnteni Installations et Conseil.

## 1.4 Structure of the Report

The report presents the findings, analyses, conclusions and recommendations of the study. In Chapter 2, the current practices on cashew waste management are presented and analyzed. After a global assessment of the cashew sector in the 8 African countries (2.1), the cashew by-product solutions and processed are introduced (2.2). Next, a comparative analysis and introduction of the Key Performance Indicators is done (2.3). Particular attention is put on the adverse environmental effects (2.4). Next, the Asian practices on waste management and by-products are presented (2.5), followed by the practices observed in the 8 countries (2.6) and concluded with a comparative analysis (2.7). The chapter closes with an analysis of the cashew by-product flow, that can be used as a framework of related solutions, key performance indicators and informed decisions.

In Chapter 3, the institutional setting, stakeholders and policies are analyzed. After the identification of the legal frameworks on environmental responsibilities, energy and carbon emission reduction and responsible regulation bodies on global level and per country (3.1), the stakeholder analysis and institutional roles and responsibilities are presented (3.2).

Chapter 4 assesses the unexploited potential of the value addition of the shells (4.1) and summarizes per country the Strengths, Weaknesses, Opportunities and Threats (SWOT) of the cashew by-products sector, consequently followed up by framing the strategic lines and most overall suitable solutions (4.2).

Chapter 5 summarizes the key findings (5.1) and recommendations (5.2) and critical success factors (5.3). Part of the recommendations is the proposed training program for stakeholders into an action plan (5.4).

For detailed information references are made to the Annexes.

# 2 Assessment of existing waste management practices

This chapter summarizes the diagnostic on waste management practices in cashew processing of the 8 countries visited. Good practices are highlighted and a comparison with the Asian practices is analyzed.

## 2.1 Overview of the African Cashew sector

Africa has now taken over as the world's largest producer of RCN. Between 2000 and 2016, production of cashews in Africa has grown by a factor of 4.5 from around 400,000 MT to an estimated 1,800,000 MT in 2016. Côte d'Ivoire and Tanzania are currently the continent's top producers.[i]

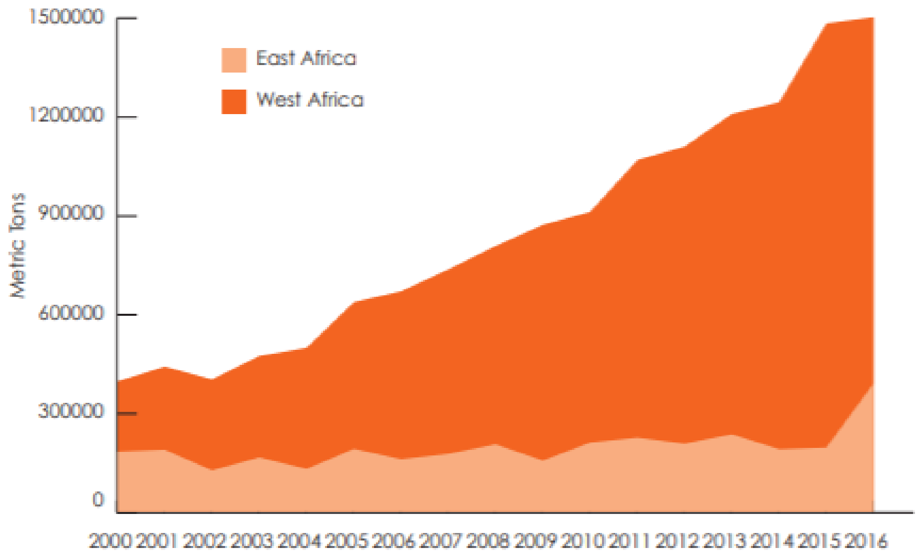


*Figure 2. Cashew produced in East and West Africa (Source: ACA, Annual report 2016)[ii]*

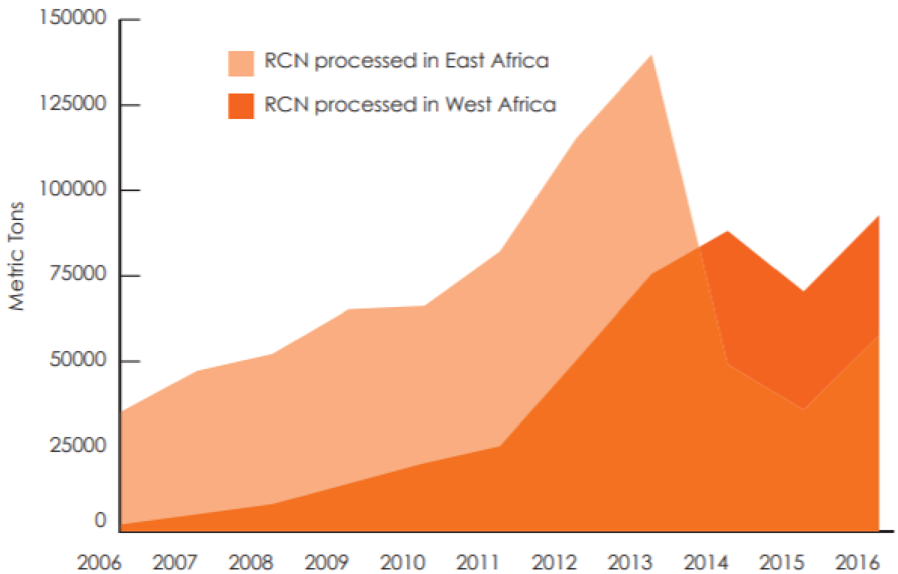


*Figure 3. Cashew produced in East and West Africa (Source: ACA, Annual report 2016)[iii]*

On basis of the presented figures in the Annual report 2016 of ACA, there is an estimated RCN quantity of 1,800,000 Mt and 150,000 Mt processed in 2016 in all African countries. Considering the collected data from the field visits, for the 8 countries, an estimated production of nearly 1,391,000 Mt RCN produced and 148,633 Mt processed in 2017.A comparison between the figures of the Annual report 2016 of ACA and the collected data during the study, we concluded that these figures are in line, taking into account that figures of 2016 and 2017 differ, that there was a limited increase of capacity per country due to a bad season in 2017, and a minor part produced and processed by the other countries (like Senegal, Togo, Nigeria and Mali).

*Table 3. RCN processed volumes 2017 vs RCN production, for the 8 selected countries.*

| Country | # of processors | Estimated RCN production (Mt)[1] | Quantity of RCN processed in 2017 (Mt)[2] | % RCN processed |
|---|---|---|---|---|
| Benin | 4 | 110,000 | 14,553 | 13% |
| Burkina Faso | 4 | 75,000 | 4,874 | 6% |
| Côte d'Ivoire | 28 | 650,000 | 52,280 | 8% |
| Ghana | 3 | 70,000 | 536 | 1% |
| Guinea-Bissau | 6 | 100,000[3] | 5,950 | 6% |
| Kenya | 5 | 6,000 | 3,440 | 57% |
| Mozambique | 17 | 130,000 | 56,100[4] | 43% |
| Tanzania | 10 | 250,000 | 10,900 | 4% |
| **Total** | **77** | **1,391,000** | **148,633** | **11%** |

Conclusion: the total quantity of RCN processed in all the 8 countries is 10.6% of the total production. Only one country (Kenya) processes more than 50% in the country of its total RCN production, whereas in Kenya the industrial capacity is already beyond the potential production. For other countries with significant quantities (Benin, Côte d'Ivoire, Tanzania) there is a relatively low processing capacity in. Mozambique is showing a steady increase in processing capacities, thanks to efforts put in the promotion of the processing sector for years now, and features the highest processing rate. Côte d'Ivoire, despite accounting for almost half of the cashew in-shell production, is only processing 8%; though capacities in the country are quickly increasing.
Considering the share of the country among the total production and processing capacity of the 8 countries, Côte d'Ivoire has half of the share in RCN production and nearly half of the share in processing capacity.

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[1] Source: ACA, Invest in Africa, Cashew, 2017 edition, Issue No.5

[2] Source: collected data on processing obtained during interviews with the processors. Processed volumes increased in 2018 in some countries, but definitive figures are still not available. The volumes indicated are the result of field interviews with processors and/or representative bodies.

[3] We maintained 100,000 Mt RCN instead of the 10,000 Mt RCN that was found in the source ACA, Invest in Africa, Cashew, 2017 edition, Issue No.5. It seemed the most straightforward and still it is conservative, because people generally estimate production in G-B at more than 150,000. Official sources are hard to find, but that was the general message from people in the country, and that's what you find in recent news: https://uniogbis.unmissions.org/en/cashew-nut-central-guinea-bissau-economy-blessing-or-curse

[4] Official numbers are slightly smaller: 48,000 to 50,000 Mt. Source: INCAJU

*Table 4. RCN processed volumes 2017 vs RCN processing capacity, by country*[5]

| Country | Estimated RCN production (Mt) | Share of total production | Processing capacity (Mt) | Share of total processing capacity |
|---|---|---|---|---|
| Benin | 110,000 | 8% | 23,500 | 6% |
| Burkina Faso | 75,000 | 6% | 15,500 | 4% |
| Côte d'Ivoire | 650,000 | 50% | 169,600 | 47% |
| Ghana | 70,000 | 5% | 23,000 | 6% |
| Guinea-Bissau | 100,000 | 1% | 12,950 | 4% |
| Kenya | 6,000 | 0% | 30,000 | 8% |
| Mozambique | 130,000 | 10% | 76,100 | 21% |
| Tanzania | 250,000 | 19% | 13,500[6] | 4% |
| **Total** | **1,391,000** | **100%** | **364,150** | **100%** |

From the factories assessed, only a few have a functional by-product technology, but still a partly solution.

*Table 5. The number of processors practicing CNSL extraction or sold to third parties per country*[7]

| Country | # processors with mechanical CNSL extraction | # processors with thermal CNSL extraction | # processors selling shells directly | Total |
|---|---|---|---|---|
| Benin | 1 | | 2 | 3 |
| Burkina Faso | 1 | | | 1 |
| Côte d'Ivoire | 4 | | 1 | 5 |
| Ghana | 1 | 1 | | 2 |
| Guinea-Bissau | | 1 | | 1 |
| Kenya | | | 1 | 1 |
| Mozambique | 1 | | | 1 |
| Tanzania | | | | |
| **Total** | **8** | **2** | **4** | **14** |

On basis of the processed RCN quantities in 2017, the assumption of 70% shell weight and the capacity of the by-product processing at each factory, there is an estimated quantity of nearly 25,000 Mt of shells that is processed. To 50% is value addition is done by CNSL extraction. A significant difference is observed between countries. In Benin, the part of shells that is processed is with nearly 10,000 Mt the highest. And still there is a potential of 35% to which value addition can be done. In Côte d'Ivoire, the quantity is extremely low (1%). Olam Ivoire, the biggest processor stopped CNSL extraction.

[5] Source: collected data on processing obtained during interviews with the processors.
[6] Considering only factories who have recently been refurbished and/or worked recently. Factories who have not been working for more than 5 years are not considered.
[7] Source: collected data on processing obtained during interviews with the processors.

*Table 6. Estimated quantity of shells processed by CNSL extraction, sales to third parties and used for own thermal energy*[8]

| Country | Quantity of RCN processed in 2017 (Mt) | Estimated quantity of shellsprocessed (Mt) | Percentage of shells processed |
|---|---|---|---|
| Benin | 14,553 | 9,136 | 65% |
| Burkina Faso | 4,874 | 1,400 | 30% |
| Côte d'Ivoire | 52,300 | 462 | 1% |
| Ghana | 536 | 375 | 73% |
| Guinea-Bissau | 5,950 | 2,331 | 41% |
| Kenya | 3,440 | 458 | 14% |
| Mozambique | 56,100 | 8,687 | 16% |
| Tanzania | 10,900 | 620 | 6% |
| **Total** | **148,653** | **23,468** | **16%** |

Nearly all factories use the cashew shells (either blended with other biomass or pure) for own thermal energy. The quantities declared are rough estimations and there is a wide range (5-25% of the shells produced).

## 2.2 Global description of cashew by products and processes

A brief description of the different cashew products with the physical and economic characteristics is presented.

The main direct products of the cashew processing, with the share in mass (in %[9]) are the

- Cashew kernel (20%), considered as the main product

And the direct by-products

- Shell (±70%), further processed into CNSL and de-oiled shells
- Testa (±3%)
- Rejected kernels (±3%)

The different technologies and processing steps of the existing practices are summarized in a by-product flow diagram. Starting with the kernel extraction from RCN (70%), there is first processing of shells with different technologies, providing mainly T-CNSL and press cake or de-oiled shells. In a second phase value addition is done by local use of thermal energy and export. Exported CNSL is supposed to be further processed into cardanol and residol.

[8] Source: collected data on processing obtained during interviews with the processors.

[9] The % are based on practical experiences of cashew processing. The total is not equal to 100% because there is a few % loss of humidity.

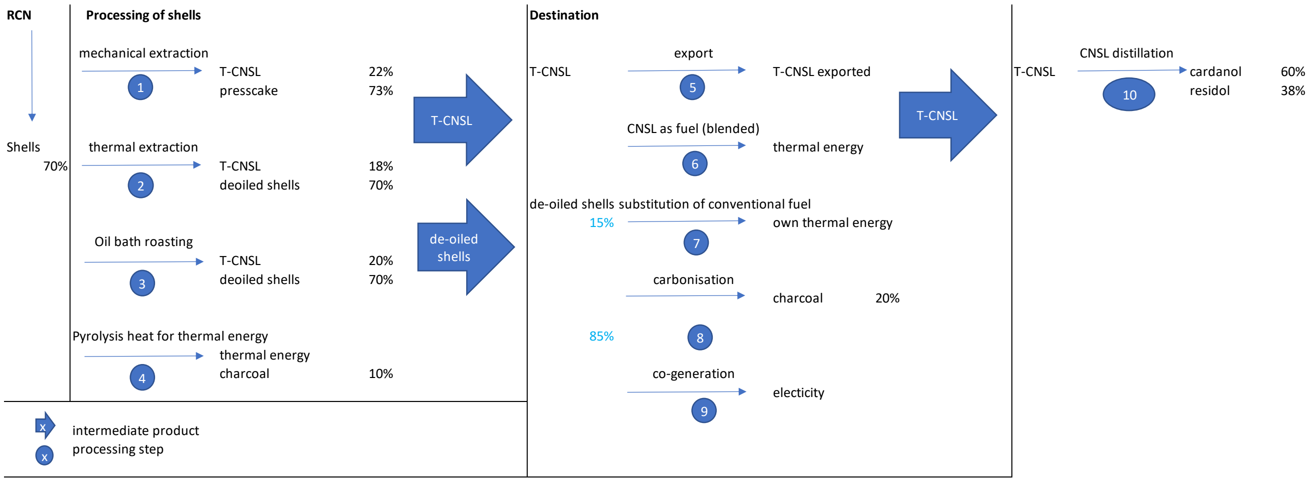


*Figure 4. Flow of the main different steps in by product processing of cashew shells*

### 2.2.1 Shells: CNSL, derivates, press cake and charcoal

The main use of shells and/or the derivates is for energy. After a first processing phase, the CNSL is extracted. Through mechanical extraction and decarboxylation, technical CNSL is obtained[10]:

1. T-CNSL (± 22%) - The characteristics of T-CNSL are presented in Annex 2.
2. Press cake (± 73%)
3. Sludge (± 5 %)

CNSL extraction is done by (Figure 4 above; 3):

- Mechanical extraction by use of screw expellers, which is a proven technology and most commonly applied,
- Thermal extraction, by heating the shells while the CNSL is leaking out from the reactor. This technology is in a development phase and needs further research and development
- Oil bath roasting (the Brazilian shelling technology) allows the CNSL to be extracted already during the roasting of the RCN

The cashew shell is the main by-product of the processing and constitutes about 70-75% of the weight of the raw nut. The oil (CNSL) of the shell is extracted and decarboxylated (about 21-23% of the weight of the shell)[11]. This technical CNSL is used in the polymer industry and is intended for export, as there is no formal client in the African countries. (Figure 4 above; 5)

#### *2.2.1.1 CNSL distillation: cardanol and residol*

Further processing of T-CNSL is not yet done on the African continent. But this option needs to be explored, as cardanol has a much higher value than CNSL (around US$700-800/Mt). (Figure 4 above; 10)

T-CNSL is further processed in a distillation plant (Batch process), with output: 60% Cardanol and 38% Residol. Equipment needed: High vacuum distillation equipment. The applications are:

1. Cardanol applications: Epoxy hardeners, Electrical insulation coatings, Fuel additives (Hydrogenated cardanol derivatives) Lubricants: (Hydrogenated cardanol), Laminating resins, surface coatings.
2. Residol applications: Acid & Alkali resistant tiles and cements. Water proofing application, Anti corrosive coatings. Can be used as binder for road construction with bitumen. Friction particles for automobile brake pads and clutch facings.

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[10] Figures are based on technically advanced CNSL extraction methods, including a sludge recovery system.

[11] The assumptions for modelling estimations are: T-CNSL: 22% and de-oiled shells: 73%

#### 2.2.1.2 Other CNSL derivatives

CNSL can be polymerized to make resins, which constitute the base of phenolic paints, epoxy hardeners, varnishes, metal and wood primers and many other surface coatings. All featuring good scratch hardness, corrosion protection, and bright gloss.

CNSL resins can be used in the manufacturing of brake pads and clutch facings as binder, friction modifier, improving the fade resistance, as compared with conventional materials.

The CNSL resin manufacturing technology is well known and has been working for about twenty years in India. Out of the CNSL producing countries, who mainly use the local CNSL available for the domestic industry, CNSL international buyers can be found in the USA, Spain, Japan and Australia mainly. The uses of CNSL in these countries are for resin manufacturing purposes mainly.

#### 2.2.1.3 The CNSL market

The most common CNSL market for African processors is the export market. Cardolite has the highest market share for CNSL buying. Since 2015 the CNSL price has dropped internationally and the extraction of the CNSL is hardly profitable for the coverage of the charges. Market prices have ranged from US$350-400/Mt CIF over the last years. As CNSL is a source of phenols, which are present in crude oil, the CNSL prices are influenced by the petrol price in the world market.

An alternative market to export is the local use of CNSL. The most direct way is the use as combustible. The processed T-CNSL can be mixed with diesel or other conventional fuels, with 37 MJ/kg heat as calorific value. T-CNSL for fuel must be in conformity to quality specifications; namely, the moisture and ash content should be minimal.

Technology is commonly available, but optimization and adverse effects are in study.

This market is still in an emergent stage. It is promising regarding the sales prices, but the adapted technology is not yet proven and needs still research and development.

Next, CNSL for other applications is a potential option. Further processing of CNSL into other products needs scale and a sustainable supply of CNSL.

### 2.2.2 Shells: source of energy

Shells can be processed directly to obtain energy and energy products. A few technologies are used for direct value addition of shells to energy:

1. The **H2CP (High Calorific Cashew Pyrolizer[12])**, where pyrolysis gas is directly used for thermal energy. Shells are fed intro the pyrolizer, and undertake a thermal decomposition thus releasing a combustible gas. Pyrolizer is used as source of heat for steam generation in the boiler; the H2CP has shown itself appropriate for cashew units up to 1,500 MT/year capacity. Several units located in urban areas are using it daily, as a technology that minimizes the disturbing fumes emissions. Other small industries neighboring the cashew units have also adopted these pyrolizers, as they require a very cheap fuel – the cashew shells are sold EW at 0 to 20 CFA/kg. Pyrolysis yields charcoal (7 to 15% on the input shells), which is given out to the workers of the factory. The charcoal is burnt in combination with conventional charcoal, or alone, thus reducing the amount of wood charcoal needed. Economic, social and environmental impacts have been outlined in an article presented in CIESA[iv] in 2017. (Figure 4 above; 4, 8)

*Figure 5. H2CP pyrolizer installed under a vertical boiler in a cottonseed oil factory in Burkina Faso; pyrolizers can be used out of cashew processing units, thus generating fuel savings to neighboring industries*

[12] It is also named gasification. The term *pyrolysis* is used in this document to refer to the locally built technology of H2CP pyrolyser, and has not a scientific sense.

2. Via a **charcoal retort**, shells are pyrolyzed and carbonized shells are obtained. The advantage is that this low technical solution does not require high investment costs and can be set up in a modular way. The charcoal yield is higher than in H2CP (around 20%), as the device is specifically designed for charcoal production. Several retorts can be managed by one operator. The resulting charcoal is smokeless and lights up quickly. This shells-for-charcoal option has at several advantages: 1) it is the easiest and cost-efficient way of managing shell waste at reduced capacities; 2) it has the potential of limiting deforestation, as shell charcoal substitutes wood charcoal. However, cashew charcoal from the pyrolysis can have a shattering effect when it burns. It is therefore recommended to grind or otherwise break it up prior to pressing into charcoal briquettes to avoid this. (Figure 1; 4, 8)

*Figure 6. Cashew shell charcoal retorts in Burkina Faso*

3. Alternatives are **gasification of the shells**, with biochar and electricity as final products. Gasification for power generation is only possible with big loads of shells. If the shells are raw (i.e. not de-oiled), the gasifier may need mixture with other biomass sources to avoid chocking. The biochar can be used as fertilizer or fuel, and electricity is used on site, substituting electricity from the other sources (e.g. the grid). Several gasifier solutions exist, in the range of 50 to 1000 kW, on different development stages. It is possible to run diesel generators in dual fuel, i.e. injecting a mix of the gasification gas and diesel, which incurs in up to 70% diesel savings. (Figure 1; 4)
4. **Power generation from direct combustion** of shells or shell cake. Two main technologies: steam engine, and turbine. Steam engine is an old and low-efficiency technology. There are little steam engine manufacturers, as the technology is progressively being abandoned because of the low yields and high maintenance costs. Turbines are proven and modern technology, but need big quantities of shells to work on a profitable basis: calculations for the size of 1,5 MWe, indicate a supply of 15,000-20,000 Mt shells per year are available, assuming that only the de-oiled shell cake is fed (around 13,000 Mt). Also, turbines are less flexible than gasifiers, meaning that little load variation is allowed, and they must be operated continuously. Power surplus shall be exported to neighboring units or to the grid. (Figure 1; 9)
5. **De-oiled shell cake is an excellent fuel**. Its heating value is 90 to 95% of that of wood. It can be used in the cashew unit and other processing factories. Shell cake can be briquetted to

facilitate handling, or simply fed to the boiler with an automatic feeder. Having a smaller content of oil than raw shells, the cake releases less fumes when burnt. (Figure 1; 7)

6. **Compost**. Shells are degradable, but this takes a long time if they are only disposed freely. Good quality compost can be produced by injecting a microbial strain. The resulting compost is pH neutral. Good results have been reported when applied to tomato and lettuce[13]. The technique has been developed by INCAJU in Mozambique and is now going commercial: shell compost would be sold at the same price than inorganic fertilizers: 45 to 60 MT per kg.

### 2.2.3 By products and waste streams of the cashew kernel

#### *2.2.3.1 Testa*

Testa generated from the peeling operation of shelled cashew nuts is the other solid waste generated from cashew processing industry. In the case of Indian cashew industry, it is better called by-product.
Because of its chemical composition (contains polyphenols such as catechin) it is used as vegetable tanning agent for leather tanning, in pharmaceutical products, and as an additive in tea bags.

Catechins are naturally occurring antioxidants. They are known to be present in tea leaves, and wine, and prunes. Cashew testa is, anyway, richer in catechins than any of these sources. Catechins are high value products, and are widely used in pharmaceutical industry in anti-ageing creams, and in food industry as food preservatives and color preservatives.

Cashew testa contains about 32% polyphenols, many of them of the nature of tannins (predominant phenols are catechin and epicatechin (> 40%) as well as polymeric proanthocyanidins (slightly less than 40%). The catechins and epicatechins are water-soluble, while other phenols, particularly polymeric phenols, are better extracted with other solvents.

The cathechins of cashew testa can also act as tanning agents for leather. The addition of a small amount of testa to the water where the skins should be soaked in for tanning, is enough to give it a correct bright. Vegetal tanning is more and more in use, as there is an increased concern about the environmental impacts of chemical use in the process. In Kenya leather tanners recently benefitted from support to green the industry, and this resulted in some of them adopting vegetable tanning[v], and exporting these products.

Testa can be also used as dry matter in composting blends. Testa is rich in minerals such as K, and is good to enrich organic substrates. Composting of testa alone or mixed has been tested in Burkina Faso[vi] and is concluding.

Other uses of testa as dying agent (reddish color), as bed for poultry, and as cattle feed, have been indicated[14].

#### *2.2.3.2 Rejected kernels and cashew kernel oil*

The cashew kernels that are not marketable are rejected from the process. These are separated in oily and other rejected kernels. Kernel oil can be extracted mechanically from these kernels.
The most common method is to press the kernels mixed with any other dry, edible material, as to prepare cattle food. As an example, rejected cashew kernels are mixed with up to 50% rice husk and then pressed with a screw press. This method gives different products:

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[13] Interview with Dr Uaciquete, INCAJU (2018)

[14] See next sections, 2.5.6 and 2.6.

- cashew kernel oil (20-25%)
- press cake (70%)
- residues (5-10%)

It is a profitable operation, if there are local customers who use the press cake as livestock feed. The cake obtained by this method should be blended with an additional 50% of maize bran, to help animals digest and better accept the meal. Cashew kernel oil is used as hand protection oil (usually together with castor oil) inside the cashew unit. Soap can be produced with the residues, thus finding a use within the factory.

Profitability of this operation is usually not big for the cashew factory, but if the sales revenues cover the expenses of the pressing, it is already an operation to envisage, because a stock of rejected kernels on the site provokes infestation on good kernels, if the deposit is close to the unit. Anyhow, rejected cashew kernels are a big opportunity for professional cattle feed makers, as a source of proteins.

### 2.2.4 Economic potential and added value of the by-product processing

Processing of a first level of the by-products at factory level is (intended to be) practiced by the cashew processing factories. The full economic potential of by product is estimated at ± US$125/Mt RCN. When all by products are processed in the first stage at factory level, a breakdown of the potential added value (in turnover) of the cashew by-products is calculated, based on the option of local sales of CNSL; and that the valuation of the shell by mechanical extraction that has a better return.

*Table 7. Breakdown of revenues obtained by first treatment of cashew by-products (Scenario 1: total transformation in the factory)*

| **1 kg RCN of which** | | | | | | |
|---|---|---|---|---|---|---|
| **0.24** | kg of kernels (including moisture) | | | Sales price product (US$/Mt) | Added value on RCN (US$/Mt RCN) | Value share |
| **0.70** | kg shell | 0.49 | De-oiled shells | 18 | 9 | 7% |
| | | 0.154 | CNSL[15] | 609 | 94 | 75% |
| **0.03** | kg testa | 0.027 | Composted testa | 92 | 2 | 2% |
| **0.03** | kg rejected | 0.008 | Kernel press cake | 111 | 1 | 1% |
| | | 0.021 | Kernel oil | 922 | 19 | 15% |
| **Total** | | | | | **125** | **100%** |

Source: Collected data from different polls and production figures from processing units in Burkina Faso and Côte d'Ivoire

Sales prices of by-products are indicative. In Annex 3 more detailed information of collected data on the available markets for the proposed by-products are presented. Currently, processing costs of cashew nuts are relatively high, and additionally, either the market for the by-products or the right technology on site is lacking. This makes the processing of by-products not profitable enough. In most cases, processing of the rejected kernels is practiced as first option.

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15 Local sales, with reference 50% of the local fuel price; in the current situation, exported CNSL at sale prices of US$350-400/Mt CNSL CIF decreases the added value.

### 2.2.5 Development of the energy potential

Cashew shells, and after CNSL extraction, the de-oiled shells, constitutes an energy source. The 8 African countries concerned are almost all energy deficit countries. Co-generation on base of cashew shells is an economically viable opportunity, though conditioned by regular supply of shells and needing the infrastructure to export the energy surplus to the grid, or to a captive consumer. Substitution of conventional energy sources contributes to pollution reduction and to the reduction of carbon emissions.

The potential energy from biomass and the reduction of carbon emissions assumes of the Lower Heating Values of the (de-oiled) shells.

*Table 8. Lower Heating Value (LHV) for the selected fuels (MJ/kg)*

| Fuel | LHV (MJ/kg) |
|---|---|
| Cashew shells | 18,9[vii] |
| CNSL | 36,1[viii] |
| Shell cake | 17,4[ix] |
| Shell charcoal | 29,9[x] |

Source: Different lab results, and literature sources

Co-generation on basis of de-oiled shells as biomass has an assumed efficiency rate of ±1 MWh/Mt that is potentially generated. The value addition of the electrical energy highly depends on the electricity demand and the conditions of the electricity transport and delivery.

The economic potential of electricity generation depends on the kWh price of the main supplier in the country. In each country, the main supplier is the national company of electricity generation, transport and distribution. In most of the countries the electricity services have undergone privatization steps, and production of electrical energy has started to be privatized. However, on transport and distribution is not liberalized or regulated, so that electricity production and supply faces still obstacles to get the energy delivered and paid for. An overview of the different average prices per country shows a significant difference between the average prices per country.

*Table 9. Average electricity tariff per country*

| Country | Average electricity tariff (US$/kWh) | Index |
|---|---|---|
| Benin | 0.30 | 118% |
| Burkina Faso | 0.43 | 169% |
| Côte d'Ivoire | 0.23 | 90% |
| Ghana | 0.27 | 106% |
| Guinea-Bissau | 0.24 | 94% |
| Kenya | 0.28 | 110% |
| Mozambique | 0.08 | 31% |
| Tanzania | 0.21 | 82% |
| **Average** | **0.26** | **100%** |

Source: World Bank, 2014[xi] (a comparison with the local tariffs of the electricity companies indicate lower tariffs; the assumption is that fixed costs are included in these tariffs)

Especially in countries with a high electricity tariff, the co-generation constitutes a better opportunity. This is the case for Burkina Faso and Benin. Studies[xii] have shown a profitable business case on co-generation, with a ROI of 3 years, with the assumption of supplying electricity to the national grid.

More specifically, substitution of DDO[16] by T-CNSL constitutes also an economic opportunity. The DDO price is related to the diesel price and depends on the local market price for diesel and for DDO. As an indication, the diesel prices per country (July 2018) are analyzed.

*Table 10. Diesel prices (USD/L) per country (July 2018)*

| Country | US$/L | Index |
|---|---|---|
| Benin | 0.95 | 93% |
| Burkina Faso | 0.93 | 91% |
| Côte d'Ivoire | 1.08 | 106% |
| Ghana | 1.05 | 103% |
| Guinea-Bissau | 1.11 | 109% |
| Kenya | 1.05 | 103% |
| Mozambique | 1.05 | 103% |
| Tanzania | 0.95 | 93% |
| **Average** | **1.02** | **100%** |

Source: Data gathering from recent country visits, cross-checked on 02/07/2018 with http://www.mytravelcost.com/petrol-prices/

The assumption is that price of DDO is 90% of the diesel price. The price of T-CNSL substituting DDO is not yet determined, as this has only been done on experimental basis. The assumption is that the T-CNSL price could be 60% of the DDO price.
From the perspective of the CNSL production, this is an interesting option, because the price is about 30% higher than CNSL for export. On top of that, logistical costs for export will be economized. There are still a couple of assumptions to clarify on blending, regulations and efficiency.

### 2.2.6 Potential reduction of carbon dioxide emission

The production of the energy, electrical and thermal, has the potential to substitute conventional (fossil) energy. Generation of conventional (fossil) energy implies the emission of greenhouse gases. The emission factors (in tCO2eq per MWh) per country for the generation of electricity are presented. The differences between countries are considerable. This is related to the energy source used. In Ghana and Côte d'Ivoire the main source of electrical energy generation is the hydro-power, that emits less GHG than conventional fossil energy generation, as it is the case in Burkina Faso.

*Table 11. GHG Emission factors in tCO2eq/MWh generated per country*

| Country | GHG Emission factor (tCO2eq/MWh) | Index |
|---|---|---|
| Benin | 0.683 | 132% |
| Burkina Faso | 0.700 | 135% |
| Côte d'Ivoire | 0.408 | 79% |
| Ghana | 0.150 | 29% |
| Guinea-Bissau | 0.518 | 100% |
| Kenya | 0.393 | 76% |
| Mozambique | 0.683 | 132% |
| Tanzania | 0.607 | 117% |
| **Average** | **0.520** | **100%** |

Source: IPCC, IFC, 2018

[16] Diesel Distilled Oil, a lower-quality fuel used in burners – in other countries, similar options are available, called either Light Fuel Oil (LFO), Refined Fuel Oil (RFO) or Light Distilled Oil (LDO)

For conventional combustibles the GHG emission factors (in tCO2eq/Mt) are only presented for the potential combustibles to be substituted by (de-oiled) shells or T-CNSL.

*Table 12. GHG Emission factors in tCO2eq/kg per combustible*

| Combustibles | GHG Emission factor (tCO2eq/Mt) |
|---|---|
| Waste Oil / Lubricants | 3.1 |
| Wood[17] | 4.6 |
| HFO | 3.12 |
| Cashew shells (when burnt)[18] | 0 |

Source: CDM - Calculating emissions from solid waste disposal; ADEME; and personal calculations based on these sources.

Substituting conventional energy sources, either electricity power or conventional fuels will have a carbon emission saving impact. The reduction of carbon emissions can be appreciated from several perspectives.
First, at factory level, there is the reduced carbon footprint with even a potential positive carbon emission balance. This contributes to the image of the cashew industry and branding of the products to customers.
Next, the surplus of carbon credits can be monetarily valued via Carbon Certification Schemes (CER/VER)[19]. Carbon credits are valued at US$11-12/tCO2eq. Related to the RCN price, it has a potential value of US$7-8/Mt of RCN.
Moreover, at a sector level, this reduced carbon footprint might be an attractive environmental impact for investors and financial institutes.
Finally, on a national level, carbon emission reduction by processing of the cashew by-products contributes to the National Determined Contributions (NDC) of each of the countries, with the horizon of 2030.

## 2.3 A comparative analysis of the unexploited potential

### 2.3.1 Key Performance Indicators of the cashew by-products

On basis of the (unexploited) potential of the cashew by-products, a couple of main Key Performance Indicators (KPIs) for value addition are identified.

1. The **economic value**: the profitability of the by-product processing and the return on investment, contributing to capitalization of private investors and economic growth of the local and national economy.

[17] Wood can be considered as a carbon-neutral fuel because trees act as carbon storage while alive. However, unsustainable sourcing of firewood is $CO_2$-emitting, as the carbon stocks are not renewed by replanting.

[18] Cashew shells are also a carbon storage. When burnt as biomass solid fuel, they can be considered as neutral-emitting. When cashew shells are dumped, they decompose releasing methane and $CO_2$, and calculated emissions are 0.10 $tCO_2eq$/Mt. Other compounds released in shell combustion, like soot (particles) are not considered GHG, but do have an effect on environmental health. For this, see Section 2.5.4.1 and ANNEXES -4. More details are available with the consultants.

[19] CER: Certified Emission Reductions; VER: Verified Emission Reductions; this part is not further elaborated in this report, as it is beyond the scope of the Terms of Reference. More details are available with the consultants.

2. The (positive) **energy balance**, considering the (electrical) energy consumed in relation to the (electrical) energy produced through the cashew by-products processing. This is contributing to avail (electrical) energy in countries where there is a low capacity and access to (electrical) energy.


3. The (positive) **carbon balance**, only direct carbon emissions are considered: emissions linked to the transportation of the products and people, electricity consumption and combustibles for thermal energy (besides the cashew by-products used for thermal energy), in relation with the produced and delivered energy by the processor or by third parties, substituting conventional energy. This is contributing to reduce and mitigate carbon emissions on national level.

### 2.3.2 The Cashew by-product KPI modelling

Considering these KPIs and the assumptions on sales and production costs, tariffs, carbon emissions (as mentioned in the previous paragraphs), a calculation model is used to generate indicative information on these KPIs. The model works with pre-established input parameters (mainly sales and production costs, tariffs, carbon emissions), disaggregated per country. Some variable input parameters are determined.

1. For the produced quantities, turnover and net profit, the input parameters are: processing capacity, the percentage of shells, technology on by-products
2. For the energy balance, the input parameters are: the total electricity consumption per year. This depends on the level of mechanization and automation, categorized in 3 'factory types':
    - Atomized: with more than 50% atomized shelling, peeling and grading
    - Semi-industrial: with atomized peeling (and grading)
    - Manual: with manual peeling and grading

   Pre-established indicative figures are provided for the electricity consumption per Mt RCN per type of factory.
3. For the carbon balance, the additional input parameters are: the distances of transport of product and people and the quantity of combustibles for thermal energy (besides the cashew by-products used for thermal energy).

### 2.3.3 Comparative analysis of the unexploited potential

With the assessment of the existing practices of the cashew by-products in the 8 countries, a global estimation is done about the economic, energetic and ecological situation.

Based on the figures declared by the different factories on their production capacity, the processed RCN quantities 2017 and the produced RCN estimation, a few scenarios for value addition of the by-products are compared. These data include the indications on the level of technology for processing of kernels and by-products. The data is aggregated on the level of 8 countries and all quantities are on yearly basis. For a comparative analysis, 4 scenarios are compared:

- Scenario 1, a reference of the current situation, based on the processed RCN quantities in 2017.
- Scenario 2, a projected situation, based on the assumption that the same quantity will be processed, but the processing of by-products will be done in an optimized way. And that the necessary investments on by-product processing will be realized for that quantity.

- Scenario 3, a projected situation, based on the assumption that the installed processing capacity will be fully utilized and investments on by-product processing will be realized.
- Scenario 4, a projected situation, based on the assumption that all RCN will be processed and investments for (by-product) processing will be realized.

It is important to remind that these estimations are based on the "most-optimized" scheme for value addition, though based on feasible propositions; this is, in brief:

- Shells being split into CNSL and shell cake,
- 50% of the CNSL being used as local fuel and the rest going on export;
- 80% of the Shell cake produced being converted into electricity, the rest is used for heat purposes at the factory

In some cases, it could be a more cost-effective solution to sell the cake as a solid fuel to feed boilers (thermal purposes). Thus, the earnings and emission savings scenario would be different. The CashUCalculator[20] tool can elaborate a first assessment of this and other study cases.

Some preliminary remarks:

- To compare the input parameters between the scenarios, the modified parameters are marked with green colored cells.
- For the % of shells for gasification and the quantity of wood for thermal energy, the quantities are insignificant and hence not considered.
- In scenario 2-4, the own thermal energy is not produced on basis of direct combustion of the shells, but on basis of the de-oiled shells
- For the calculated carbon emissions due to transport of product and people, an overall estimated average distance of transport of RCN, kernels and people is kept the same for all scenarios. By modelling specific cases, these input variables can be filled in.
- The quantity of energy produced is the sum of electrical and thermal energy. For the Energy balance, the sum of thermal energy and electrical energy is considered.
- The net profit is directly correlated to the turnover. There has been no cost calculated for the disposal of shells.

[20] The CashUCalculator is a tool, developed by Away4Africa, to assess the KPIs on cashew by-products. The tool is available online at https://www.away4africa.nl/CashUCalculator/Account/Login

CashUCalculator
The CashewCalculator
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**Scenario 1: Current situation**

*Table 13. Processing parameters for current (by-product) processing of the factories in the 8 countries*[21]

| Processing parameters | Input | Unit | Reference value |
|---|---|---|---|
| Processing capacity (in RCN/yr) | 148,653 | Mt | |
| The % of shells from RCN | 70 | % | 70% |
| % of shells for CNSL extraction (mechanical) | 12 | % | |
| % of shells for CNSL extraction (thermal) | 2 | % | |
| % of shells for gasification | 0 | % | |
| % of shells sold directly | 5 | % | |
| % of shells for own thermal energy | 4 | % | 15% |
| Quantity of wood for own thermal energy | 0 | Mt | |
| Mechanization level | semi-industrial | | |
| Electricity consumption factory | 18,579,125 | kWh | 125 kWh/Mt RCN |

| Output | Quantity | Unit |
|---|---|---|
| Quantity of shells | 104,057 | Mt |
| Quantity of shells (for mechanical extraction) | 12,487 | Mt |
| Quantity of shells (for thermal extraction) | 2,081 | Mt |
| Quantity of shells (for gasification) | - | Mt |
| Quantity of shells sold directly | 5,203 | Mt |
| Quantity of shells for own thermal energy | 4,162 | Mt |
| Quantity of T-CNSL | 2,747 | Mt |
| Quantity of electrical energy produced | 7,143 | MWh |

| KPIs | Quantity | | Added value to RCN (US$/Mt RCN) |
|---|---|---|---|
| Total energy balance | 10,906,156 | kWh | |
| Quantity of carbon credits | -9,577 | tCO2eq | |
| Total sales | 2,275,170 | US$ | 15 |
| Total net profit | 496,251 | US$ | 3 |
| Carbon emission allowance saving potential | - | US$ | - |

*Preliminary conclusions of Scenario 1:*

- *There is a positive energy balance of 10,906 MWh per year, needed for (electrical) energy for processing*
- *There is a negative carbon credit balance, with a yearly carbon emission of 9,577 $tCO_2$-eq*
- *There is a value addition of US$2,2m, with a rough estimated net profit for the businesses of US$496k*

[21] Source: collected data on processing obtained during interviews with the processors.

**Scenario 2: Potential of value addition of the shells, based on the 2017 processed quantity of RCN**
Another scenario is projected, based on the assumption that the complete potential quantity of shells is processed : through CNSL extraction (with 50% substitution of DDO), and 80% of the de-oiled shells used for co-generation, while 20% is used for own thermal energy.

*Table 14. Processing parameters for potential (by-product) processing of the factories in the 8 countries*

| Processing parameters | Input | Unit | Reference value |
|---|---|---|---|
| Processing capacity (in RCN/yr) | 148,653 | Mt | |
| The % of shells from RCN | 70 | % | 70% |
| % of shells for CNSL extraction (mechanical) | 98 | % | |
| % of shells for CNSL extraction (thermal) | 2 | % | |
| % of shells for gasification | 0 | % | |
| % of shells sold directly | 0 | % | |
| % of shells for own thermal energy | 0 | % | 15% |
| Quantity of wood for own thermal energy | 0 | Mt | |
| Mechanization level | semi-industrial | | |
| Electricity consumption factory | 18,579,125 | kWh | 125 kWh/Mt RCN |

| Output | Quantity | Unit |
|---|---|---|
| Quantity of shells | 104,057 | Mt |
| Quantity of shells (for mechanical extraction) | 101,976 | Mt |
| Quantity of shells (for thermal extraction) | 2,081 | Mt |
| Quantity of T-CNSL | 22,435 | Mt |
| Quantity of electrical energy produced | 58,332 | MWh |

| KPIs | Quantity | | Added value to RCN (in US$/Mt RCN) |
|---|---|---|---|
| Total energy balance | 211,081,630 | kWh | |
| Quantity of carbon credits | 58,560 | tCO2eq | |
| Total sales | 18,534,402 | US$ | 125 |
| Total net profit | 4,156,342 | US$ | 28 |
| Carbon emission allowance saving potential | 702,721 | US$ | 5 |

*Preliminary conclusions of Scenario 2:*

- *There is a positive energy balance of 211,081 MWh per year, generated as (electrical) energy, while energy for processing is coming from the by-products*
- *There is a positive carbon credit balance, with a yearly carbon emission saving of 58,560 tCO2-eq*
- *There is a value addition of US$18.5m with a rough estimated net profit for the businesses of US$4.2m*

**Scenario 3: potential of value addition of the shells, based on the present installed processing capacity**

Another scenario is projected, based on the assumption that the complete potential of installed processing capacity is processed: through CNSL extraction (with 50% substitution of DDO), and 80% of the de-oiled shells used for co-generation, while 20% is used for own thermal energy.

*Table 15. Processing parameters for potential (by-product) processing of the factories in the 8 countries*

| Processing parameters | Input | Unit | Reference value |
|---|---|---|---|
| Processing capacity (in RCN/yr) | 369,950 | Mt | |
| The % of shells from RCN | 70 | % | 70% |
| % of shells for CNSL extraction (mechanical) | 98 | % | |
| % of shells for CNSL extraction (thermal) | 2 | % | |
| % of shells for gasification | 0 | % | |
| % of shells sold directly | 0 | % | |
| % of shells for own thermal energy | 0 | % | 15% |
| Quantity of wood for own thermal energy | 0 | Mt | |
| Mechanization level | semi-industrial | | |
| Electricity consumption factory | 49,618,750 | kWh | 125 kWh/Mt RCN |

| Output | Quantity | Unit |
|---|---|---|
| Quantity of shells | 277,865 | Mt |
| Quantity of shells (for mechanical extraction) | 272,308 | Mt |
| Quantity of shells (for thermal extraction) | 5,557 | Mt |
| Quantity of T-CNSL | 59,908 | Mt |
| Quantity of electrical energy produced | 155,766 | MWh |

| KPIs | Quantity | | Added value to RCN (in USD/Mt RCN) |
|---|---|---|---|
| Total energy balance | 563,653,966 | kWh | |
| Quantity of carbon credits | 156,407 | tCO2eq | |
| Total sales | 49,493,051 | USD | 125 |
| Total net profit | 11,099,134 | USD | 28 |
| Carbon emission allowance saving potential | 1,876,886 | USD | 5 |

*Preliminary conclusions of Scenario 3:*

- *There is a positive energy balance of 536,653 MWh per year, generated as (electrical) energy, while energy for processing is coming from the by-products*
- *There is a positive carbon credit balance, with a yearly carbon emission saving of 156,407 tCO2-eq*
- *There is a value addition of US$49.5m with a rough estimated net profit for the businesses of US$11m*

**Scenario 4: potential of value addition of the shells, based on the present RCN production being processed**

Another scenario is projected, based on the assumption that the totality of the RCN produced in the 8 countries is processed, and shells are at maximum valorized: through CNSL extraction (with 50% substitution of DDO), and 80% of the de-oiled shells used for co-generation, while 20% is used for own thermal energy.

*Table 16. Processing parameters for potential (by-product) processing of the factories in the 8 countries*

| Processing parameters | Input | Unit | Reference value |
|---|---|---|---|
| Processing capacity (in RCN/yr) | 1,391,000 | Mt | |
| The % of shells from RCN | 70 | % | 70% |
| % of shells for CNSL extraction (mechanical) | 98 | % | |
| % of shells for CNSL extraction (thermal) | 2 | % | |
| % of shells for gasification | 0 | % | |
| % of shells sold directly | 0 | % | |
| % of shells for own thermal energy | 0 | % | 15% |
| Quantity of wood for own thermal energy | 0 | Mt | |
| Mechanization level | semi-industrial | | |
| Electricity consumption factory | 173,875,000 | kWh | 125 kWh/Mt RCN |

| Output | Quantity | Unit |
|---|---|---|
| Quantity of shells | 973,700 | Mt |
| Quantity of shells (for mechanical extraction) | 954,226 | Mt |
| Quantity of shells (for thermal extraction) | 19,474 | Mt |
| Quantity of T-CNSL | 209,930 | Mt |
| Quantity of electrical energy produced | 545,837 | MWh |

| KPIs | Quantity | | Added value to RCN (in US$/Mt RCN) |
|---|---|---|---|
| Total energy balance | 1,975,167,317 | kWh | |
| Quantity of carbon credits | 548,135 | tCO2eq | |
| Total sales | 173,435,122 | US$ | 125 |
| Total net profit | 38,894,403 | US$ | 28 |
| Carbon emission allowance saving potential | 6,577,622 | US$ | 5 |

*Preliminary conclusions of Scenario 4:*

- *There is a positive energy balance of 1,975 GWh per year, generated as (electrical) energy, while energy for processing is coming from the by-products*
- *There is a positive carbon credit balance, with a yearly carbon emission saving of 548,135 $tCO_2$-eq*
- *There is a value addition of US$173m with a rough estimated net profit for the businesses of US$39m*

Conclusions and observations on the comparative analysis of the scenarios:

- Comparing the first two scenarios, there is an unexploited potential of US$16m, or US$110/Mt RCN of turnover that is not exploited in the current situation. For the factories it is a missed potential of US$25/Mt RCN. Scenario 3 and 4 are based on the same technological assumption, that the added value per Mt RCN remains the same. There is a potential value addition of US$170m with a rough estimated net profit for the businesses of US$39m.
- The value addition of the cashew shells can contribute to a positive energy balance that varies from 211,081 MWh to 1,975 GWh
- The value addition of the cashew shells can contribute to a positive carbon balance that varies from 58,560 to 548,135 tCO2eq.

The necessary investments depend on the market demand, the choice of technology and the business environment. Explorations are done, but it is beyond the scope of this study to elaborate the investments, as they are context specific and time bound. More information is available with the consultant team.

## 2.4 Environmental adverse effects of cashew processing

### 2.4.1 Waste water

Processing units produce different types of waste water. The most prominent is the waste water of the cooking pots at the roasting stage. Condensed water and leaked CNSL from the shells is mixed. This waste water containing CNSL is inconvenient for the environment. To remedy this, it must be treated before evacuating. For this, a simple treatment by decanting and phyto-purification proved effective when practiced in Burkina Faso.

*Figure 7. Construction of septic tanks for water treatment*

### 2.4.2 Air pollution

Air pollution is provoked by the exhaust gases from the boiler. Using the shells as combustible is the most common practice. The CNSL is not burnt completely in the combustion process and generates black smoke. To avoid this black smoke, some of the factories located near population settlements use wood, which causes fewer nuisances to the neighborhood. The other solution is the extraction of the CNSL and use of the de-oiled cake.

Achieving 100% clean fumes is possible no matter the fuel used, by means of a gas cleaning system – compact cyclones and gas scrubbers can be easily manufactured locally.

Although the fumes are a nuisance to the neighborhood, the particles (soot) emissions remain below the threshold[xiii]. We must recall that the smoke emission occurs for a few hours per day only; so, the daily average shows very low values.

The use of scrubbers is recommended to eliminate up to 90% of the particles, and with them the related nuisance odor. The cost of a gas treatment system may vary between 800,000 and 1.2 million CFA.

### 2.4.3 Disposal of shells

The current situation at most factory sites is a deposit of shells on site. Exposed to weather conditions, sun and rain, the CNSL is leaking into the soil. Surplus of rain water drains the CNSL via surface to downwards. Even if it is true that CNSL would join the soil, it must be recalled that CNSL is biodegradable[xiv]. There is no evidence that shows a correlation between CNSL infiltration and pollution of deep ground water. However, contact of leaked CNSL with surface water would cause pollution, and must be avoided. Therefore, in case shells are deposited, some considerations are to be considered[xv]:

- depositing shells at a waste disposal site to avoid run-off, and if necessary, include a containment berm around the area and a sump to capture run-off.
- building containment barriers around existing dump sites.
- loading waste in layers, not too thick (50 cm) with alternating bands of soil (10-20 cm) to improve conditions for on-site decomposition.
- adding another agriculture-based waste product as alternate layer to buffer acidity of cashew shell waste.

A low-tech alternative to disposal is composting. Cashew shell can become a substrate for compost (see Section 2.2.2, point 6).

## 2.5 Asian practices of cashew by products and waste

For the Asian practices, reference is first made to India.

### 2.5.1 Organization of the industry and the cashew nut shell

First, cashew nut shell is considered as by product from the industry in India, not a waste produced from the industry. It is an additional revenue source for the cashew industry to meet overhead expenditure.
India is one of the largest producers, consumers and exporters of cashew in the world. According to Indian Cashew Export Promotion Council, India accounts for over 60% of the world exports of cashew kernels[xvi]. Raw Cashew Nut crop cultivation in a country like India is not sufficient for processing industry and most of the processing requirements are met by importing Cashew Nut from Africa.
In terms of processing, the country is a world leader, reaching both domestic and export market. These volumes are matched by a variety of processors, ranging from the cottage, familiar business, to the big mechanized units (see table below for the terminology).

*Table 17. Comparison of different types of processing factories in India*

| Type | Capacity (MT RCN) | Main features |
|---|---|---|
| Cottage | 5 to 10 per month | Many of them only participate in one processing step (e.g. only shelling)<br>Manual work |
| Small scale | 25 to 100 per month | Manual work is preferred |
| Medium scale | 1000 to 5000 per year | Mechanical work is preferred, but manual is always an option |
| Large scale | > 5000 per year | Mechanical work is preferred |

Cashew nut industries are mostly in small scale and cottage sector. Only a small number are medium scale and many few large-scale production units. The main difference with African processing sector is that the small-scale units tend to be concentrated in one area, called cluster. One cluster can gather hundreds of small and cottage scale units, without excluding the possibility of featuring bigger size ones. As they are in big number, and located near populated zones, the access to the cluster is easier, and the commercial relations amongst the units are common: for example, sub-contracting of one processing step like cooking and shelling to a neighboring unit. Collection of waste is also facilitated.

There are around 2000 cashew nut processing units in India, mainly concentrated in the southern half of the country. There are about 320 units scattered in Tamilnadu, about 220 units in Kerala and about 500 units at Palasa-Kasibugga cluster, (Andhra Pradesh state) and 150 units in other parts of Andhra Pradesh. Presently, there are 175 cashew processing units in Karnataka (in the coastal districts of Mangalore, Udupi and North Kanara). As on date, there are more than 350 cashew processing industries in Odisha[22] and 40 units in Goa. There are 205 cashew processing units in Maharastra. Minor processing points can be found in Gujarat state. All over the country, 90% of them are small/cottage industries.

Most often CNSL processors are separate from cashew units. Some examples: Adarsh chemicals sanoor ltd, Sathyashree cashew.co, Sree Rama oil Pvt Ltd, Sridevi oil mill PVt Ltd. However, some big producers make their own CNSL extraction (Examples: Rajkumar Impex (Tuticorin), with 200 Mt RCN/day and a 6 MW power generation plant; Vijaya Laxmi cashew industries Ltd (Kerala)). The case

[22] Source: Odisha Cashew Processing Association

of Rajkumar is paradigmatic, as the factory also counts with a power generation plant, fed from de-oiled cake, to handle the growing power requirements for the cashew plant.

#### *2.5.1.1 The roasting process*

Due to the essential difference in the roasting process, the quality of the shells is different, and so it is with the uses:

1. *Cashew nut shell from Steam roasting process*: Shell generated from the RCN conditioned by steam roasting is suitable for extraction of CNSL and having a market demand in India. This shell will be readily sold to CNSL extraction plants at good price. Most of the units sell their shells to extraction plants, who collect them periodically at their venue. Cashew shells are rated US$ 90-95 per Mt at factory gate.
2. *Cashew nut shell from Drum roasting process*: Burnt shell generated from drum roasting process is used as fuel, as this shell is not suitable for extraction of CNSL. Some units doing cooking process and having hot air type ovens would buy the spent shells to fire their ovens. Some units are using this shell in gasifiers, and producer gas is used as a fuel for boilers.
3. *Cashew nut shell from Oil bath process*: Although this method is only used by large factories, as it is a continuous process, feasible for very high volumes. After weakening with the oil bath, shell still contains about 15% oil inside. The rest of the oil will be extracted by cold screw press. This is the case of Rajkumar Impex Pvt Ltd.

#### *2.5.1.2 CNSL extraction*

CNSL extraction is done by mechanical means – cold screw press. Raw CNSL extracted by this means is around 23%. After decarboxylation, the yield is 90 % technical CNSL from raw CNSL. CNSL is sold at around US$350-400/MT (EW) mainly to domestic market, for manufacture of derivatives, such as friction particles, cardanol, and resins for paints and coating industry. The CNSL demand is growing year after year, globally. This situation has compelled the Indian government is protecting the domestic CNSL extraction industry, by setting up an import tax to coming CNSL of 17%.

The second product of CNSL plants is de-oiled shell (also called shell cake). CNSL content in the de-oiled cake is rated at 5% to 6%. Extraction by solvents from the cake is possible, but it is not economically viable due to the actual prices of CNSL. Some solvent extraction units were opened in Andhra Pradesh state, but due to high running costs, they are not running currently. Being less polluting than raw cashew shell, shell cake will be sold as a bio fuel to industries having boilers and furnaces, at the price of US$ 45 to 50 per MT. Industrial sectors buying it are typically energy intensive: tile factories, cement factories, kilns (vegetal charcoal making…). Cashew processors are buyers of shell cake, too; in fact, processors sell the shells and buy the cake in return from the CNSL plants.

#### *2.5.1.3 CNSL derivates*

CNSL is a raw material for many products, such as paints, varnishes, brake linings, or epoxy hardeners. It can also be used raw as core oil in steel melting industry; or mixed with a conventional fuel up to 90% CNSL, for use in industrial burners. CNSL distillation process separates the major component, cardanol, from the heavier ones. Cardanol is used as raw material for polymers. The heavy fraction, called residol, is used for making acid and alkali resistance tiles used for industrial effluent tanks and industrial flooring, waterproofing compounds. The tiles do not need baking, they are only compressed. Example: Cumi-Prodorite Ltd, in Chennai, is manufacturing this kind of tiles. Residol-based resins are also used in roofing as filler against cracks.

*Figure 8. Tank foundation with acid resistant bricks*[xvii]

*Figure 9. Brick lining of underground tank*[xviii]

### 2.5.2 Institutions and control bodies

#### *2.5.2.1 The Environmental Protection Act (EPA)*

The legal frame regarding environment regulation in India is issued from the Environmental Protection Act (1986). EPA and the subsequent laws (arising from it) regulate the environmental aspects of land, air and water:

- Water (Prevention and Control of Pollution) Act, 1974;
- Air (Prevention and Control of Pollution) Act, 1981
- Hazardous waste Rules, 1989
- Environmental (Protection) Rules, 1986

No person carrying on any industry, operation or process shall discharge or emit or permit to be discharged or emitted any environmental pollutants more than the prescribed standards.

### 2.5.3 Pollution Control Boards

The Central Pollution Control Board (Central PCB) is the nation-wide pollution monitoring authority in India, and each state is having its own Pollution Control Board (PCB). All state PCBs work under Central PCB, the latter being in New Delhi, India.
The Central and State Pollution Control Boards were set up for enforcement of the Water (Prevention & Control of Pollution) Act, 1974. Over the years, the Boards have been assigned additional responsibilities which include (but are not restricted to) water, air, Municipal Solid Waste and Hazardous and other waste.

State PCBs are charged of monitoring the environmental performance of private actors, such as cashew industry. PCBs are not sanctioning authorities, but public organizations intending to assess pollution with the aim to raise awareness amongst both institutional and individual actors, either public or private. Central PCB emits recommendations that may lead to legislation further on.

*Table 18. Comparison of Central and State PCBs*

| Central Pollution Control Board | State Pollution Control Boards |
|---|---|
| **Functions** | |
| Advise the Central Government on matters relating to pollution | Advise the State Government on matters relating to pollution and on siting of industries |
| Coordinate the activities of the State Boards and provide technical assistance to them | To carry out inspection |
| Carry out and fund investigations and research relating to control of pollution | |
| Plan and organize training for public and private entities | |
| Collect, compile and publish technical and | Collect and disseminate information and statistics |

| | |
|---|---|
| statistical data, and other dissemination documents, such as manuals and codes of conduct | from the monitored State |
| Set up nation-wide standards | Develop standards applying to the State, according to the mandate of Central PCB |
| Plan nation-wide policy for pollution control | Plan policy for pollution control at State level |
| Funded by | |
| Central Ministry of Environment & Forests (100%) | State Governments and from reimbursement of Water Cess (up to 80%) collected by the respective State Boards |
| | Fees collected from the industries for issuing consent regarding discharge of effluent and emissions |

Pollution Control Boards are giving instructions to processors to use cashew shell cake instead of roasted shells in their boilers. Shell cake can also be briquetted, for use in smaller appliances or combustion devices used in residential zones, like bakeries and hotels. Big industries use cashew shell cake as a substitute for coal, due to reduced emissions of particulate matter and Sulphur, mainly.

When it comes to starting up a new cashew processing facility, the agreement from the PCB is a first step in the procedures to establish a new industrial business. For the detailed environmental standards for a cashew processing facility, see Annex 6. To obtain Permission of establishment, the project document of the new cashew unit is to be submitted to the Industries Department. The PCB will study the project details in a first step, and check if the environmental aspects of the project are considered and abiding by the law. Some of these aspects are related to waste: a procedure and the eligible facilities must be planned regarding effluent treatment and other solid waste streams. After reception of the project, PCB will give instructions for improvement, if eligible. Only once the agreement from the PCB is given, Industries Department starts the remaining procedures: Factory registration, Permission of commissioning. No new factory can establish without the agreement of the PCB, nor can new bank accounts be created in the name of the brand, if the PCB agreement is not validated.

### 2.5.4 Waste management practices

#### *2.5.4.1 Flue gases*

Gas emissions are originated in different process. As indicated above, there are two different methods for weakening the RCN, and two types of drying oven. All of them need a heat source, either hot air, direct fire, or steam. Consequently, fuel is needed. A comparison of the stack emissions measured by Central PCB for each process option can be found in Annex 5

According to Central PCB, small scale units located far from residential areas do not present harm to the environment. Using the roasting process, the emissions are limited to 4 to 6 hours per day, which does not have relevant impact on ambient air quality. The pollutants will be properly dispersed into the atmosphere, provided that the standard stack heights are respected (see Annex 5, Table 22). The problem arises in the clusters, as many units would send black smoke at the same time, leading to unacceptable particulate matter content in ambient air.

This data explains the recent decision of PCBs to ban Roasting process; and the efforts of Indian Government to promote a switch to Steam cooking in the existing units. Indeed, the Indian Government put in place a support mechanism for processors, via tax reduction and direct subsidy, to promote this change.
Additionally, it is a recommendation of the Central PCB to install a wet scrubber (Venturi scrubber)[xix] in order to reduce up to 95% the particulate matter of the stack fumes, and achieve the particulate matter emission thresholds (Table 22 below). Venturi scrubbers are of easy construction and only need a small circulating pump and a blower as electrical appliances.


*Figure 10. Scrubber installed in India*

### 2.5.5 Waste water

Environment (Protection) Act states that quality of wastewater should comply with the regulations (Annex 6); however, general practice is that the small/cottage scale cashew industry waste water is discharged to the ground without any prior treatment. However, the waste water generation from cashew nut cooking or roasting is of batch type (4 to 6 hours per day). It is a very small quantity to produce a change in ground water, if landfilled.
Large scale and medium scale plants are having their own treatment plants and giving pre-treatment before discharging the water in the sewer to comply the environmental regulation. Mainly, units (small and bigger ones) are using filter beds (sand, charcoal, salt, stones) complemented with settling tanks to manage discharge water to ground. It is a cost-effective method of waste water management. In order to obtain the Consent for Establishment waste water process are required by State PCBs; but this is only applied to medium and large-scale processors.

PCBs are promoting common Effluent Treatment Plants (ETPs) in cashew poles, like it is already being done in chemical industry areas. The operation of the ETP is private, and the users pay for the water treatment proportionally to the type and volume of effluent. PCB is in charge of the follow-up and quality check of final effluent. Nowadays, no ETP is in place in any cashew processing cluster, but their creation will be a trend in the years to come.

### 2.5.6 Testa (cashew husk)

In India, there is an industrial catechin extraction unit using cashew testa in Hyderabad and Ahmedabad. The catechin is sold for pharmaceutical use.
In India, all the testa generated from the cashew industry in the area will be collected by agents, who sell it to domestic market and export to other countries for the utilization in tanning industry. The price of dried testa is around US$615/MT.

### 2.5.7 Rotten kernels and other cashew kernel waste

In India, fine powder from cashew kernels coming from the sieving in the packing section is sold to sweet shops.

Bigger pieces of non-commercial kernels are sold to oil extractors. Oily bits are separated from non-oily ones into a different category, as the oily kernels are not edible. In one way or another, all are sold. Thus, rotten kernels and other cashew kernel waste are readily sold to the buyers and having market demand in oil extraction. Oil is used in soap manufacturing and kernel cake is used as poultry and animal feed. For example, the purified kernel oil for human consumption is purchased at around US$1/L when sold in gross, but refined cosmetic quality oil can attain US$100-500/L, sold in small bottles.

All the solid cashew by-products generated from cashew industry in India are sold and there is no dumping of any solid waste. In general, for other solid waste disposal, i.e. ash generated from the boiler, it should be properly landfilled with necessary precautions so that there are no secondary air emissions.

### 2.5.8 Main features of the Indian by product industry

Indian cashew processing sector emerged as soon as 1930. Since then, the processing methods have changed very little, in order to keep employing big quantities of workers. Still, its main features are:

- Cashew processors tend to concentrate in processing areas, called clusters. Only after the global trend switch favorable to Vietnamese processing model, who brought to failure of many small Indian businesses, the Indian cashew industry is being restructured. This implies a bet for higher automation, thus a jump in scale: the trend is to upscale and mechanize the factories. From a waste management point of view, the big volumes of solid waste (rather by-products): shells, peelings and discarded kernels are easier to collect. However, the exhaust fumes and waste water cumulate in the areas and can become a concern to populations around.
- Plus, clusters are in well-deserved areas. Even scattered units are generally of easy access, as Indian transport infrastructures are more developed than African ones. So, the collectors can come and collect the by-products from the factories, for further processing.
- Indian industrial fabric is generally stronger than African, and Indian economy is dynamic. This means more entrepreneurship and access to funding for Indian entrepreneurs, compared to Africa. Added to the fact that cashew industry is rather young in Africa, there is still not a culture in society to develop further the by-products.
- Research institutions also contributed and still contribute to adding value to the solid by-products. For example, the use of CNSL as a resin for brake linings was developed in RRL, Tamil Nadu.
- Indian Government considers cashew industry as a key sector, in part because of the high labor intensity. However, as pollution problems arise, official institutions as PCBs come to regulate and give technical support to the processing units to reduce pollution. PCBs have, indeed, as one of their main missions, the assessment and the creation of statistical data, to help in decision making.
- In India, drum roasting method is still dominating, at least in cashew family businesses. As the remaining shells are readily available and burn well, it is a common fuel, even out of cashew industries. Spent shells have a market value. However, the use of shells with this quality is causing air pollution problems. This is the reason why Indian legislators banned the use of this method in any new factory. The bid is for steam cooking process, which is less pollution intensive; and leads to a more valued by-product: shells from steam roasting contain extractable CNSL, so they will be sold at higher price than grilled ones, and will only be finally used as fuel in the form of cashew cake, i.e. a clean product.

- Wherever shells are available, CNSL extraction plants are set-up in the proximities, or even in the facilities of the cashew processing plant; CNSL extraction is highly profitable. Cardanol from CNSL distillation is an even higher value-added product.

To summarize, a SWOT analysis on the cashew waste management situation in India.

| **Strengths** | **Weaknesses** |
| --- | --- |
| - No solid waste; only gas and liquid effluent are considered waste<br>- Indian institutions support the industry in the environmental side amongst others | - Most of the processing units are still small scale, which means low-tech and less care taken to environmental management of the waste streams.<br>- Corruption on environmental results has been reported: PCBs may give a good environmental feedback to a processing unit, even in the case of bad practices, in exchange of money. |
| **Opportunities** | **Threats** |
| - Added value created by by-products: cosmetics (kernel oil), polymers (CNSL), bio fuels (CNSL), dyes (testa). | - Bad air quality in the vicinities of the clusters. This is changing slowly as no coercive measures are taken to finish with roasting process. |

## 2.6 Current practices of by cashew by products in African countries

### 2.6.1 In general

A comparative analysis of the status of the cashew by-products leads to a couple of general conclusions:

1. The extraction of CNSL is done by a few processing factories (± 10%). T-CNSL production from shells is destined for the export market: the current CNSL processing is done by the factories themselves. Some of the factories processed in the past, but stopped processing because of the low CNSL price. There are also issues which relate to the technology and equipment. The press needs to be from hardened steel, which is not easily available in the countries. The technology of the quality control requires lab equipment that is not easily available in the countries. Next, for the landlocked countries the logistical costs are relatively high. The press cake as by product of the pressing is not processed with added value, in none of the factories.
2. In terms of global by-product solutions in the cashew sector, Benin is considered as the most advanced, along with Guinea-Bissau. This assumes that the best solution on cashew by-product is the combination of CNSL extraction and co-generation. In Guinea-Bissau, there is a working facility generating electricity and heat for an industrial process, working on shells (see Section 2.6.6). In Benin, the option of co-generation is most advanced. The global framing - an MCC[23] project - facilitates investments and technical assistance on co-generation (see Section 2.6.2). The policy of electricity supply to the grid is an obstacle and considered as a risk factor for investments.

[23] Millennium Challenge Corporation. Benin is a beneficiary of the *Millennium Challenge Account Benin II*, aiming to increase the domestic power production capacity and energy efficiency in 5 years. See more at: http://www.mcabenin2.bj/

3. In Burkina Faso, the cashew processing sector has a relative big experience in R&D and testing of technologies (H2CP, charcoal retort, CNSL-fuel option). Also, the extraction of kernel oil and sales of the kernel press cake is practiced for years in Burkina Faso.
4. In Kenya, there are opportunities in terms of policy and access to biomass technologies, but the cashew sector suffers from unreliable RCN supply, constituting a considerable risk for investments in the cashew processing industry and by-product processing. Kenya has the most advanced Environmental regulations, including standards and verification protocols. On carbon emission reduction, Kenya has and relative advanced position with 40 CDM approved projects and a functional Climate Investment Fund. Testa is used for tanning in Kenya.
5. Côte d'Ivoire has the largest potential to apply the by-product solutions and businesses and create value addition, taking into account the largest RCN produced quantity and the potential industrial growth. The cashew sector has its priorities now on the RCN supply (price stabilization and crop finance) for processors. The strategy for creating processing hubs (at the capacity of ~100.000 Mt RCN/yr) creates a potential setting of by-product value addition.
6. Having the biggest processing capacity, Mozambique still has an unexploited potential for cashew by-products. Average factory size is big, meaning that CNSL extraction and even power production from excess shells/cake is possible. Industrialists are not encouraged to invest on this because the legal frame is not conducive (*see country report)*.
7. Guinea-Bissau possesses the only power production plant (CHP, Combined Heat and Power) running on cashew shells in all Africa. However, the efficiency of this system is very low.
8. In countries like Mozambique and Tanzania, where population density is low, combustion of shells in open pits is a common practice. This is still a bad practice and it is in principle not tolerated by authorities.

*Table 19. Overview of the current practices in the different African countries*

| Country | Benin | Burkina Faso | Côte d'Ivoire | Ghana |
|---|---|---|---|---|
| **Installed capacity (2017)** | 31,500 MT/year | 10,000 MT/year | 153,000 MT/year | 25,000 MT/year |
| **Real quantity processed (2017)** | 13.571 MT | 4.000 MT | 45.000 MT | 540 MT |
| **Shells** | Processing factory who did CNSL production, was Fludor; other factories sell the shells to Fludor; prospection of co-generation plant installation is done; Nad & Co applies the pyrolizer. | Small CNSL production at Anatrans. Gebana uses the pyrolizer to feed the boilers (25% of total shells). Some shells are sold or given out, in small quantities, to local industries (soap, oil, mango drying). The rest is landfilled or burnt. | Processing factories who did CNSL production, were OLAM and SITA, but they stopped because of level of the CNSL price; for now, all processing units burn or remove the shells. Removal of shells costs are 2000 FCFA/Mt. | The biggest processor, Usibras, sells shells to neighboring cocoa factory Cargill for their biomass boiler |
| **Testa** | Disposal at 100% | Disposal at 100% | Disposal at 100% | Burnt into boiler or disposed |
| **Rejected kernels** | Pressing of the kernels not really practiced | Pressing of the kernels at 100%, for kernel oil, processed into soap and feed stock | Rotten and discarded kernels have a market locally, for chicken and pork feed. The discarded bits are sold to growers at CFA 60 to 100 per kg | Burnt into boiler or sold to chicken growers |
| **Smoke** | Where pyrolizers are installed, the smoke is clean, but with the direct burning of shells, smoke is polluting; Fludor has a clean system for their boilers | For fumes reduction, a variety of fuels is used in boilers: they run on wood / shells and pyrolysis gas | On treatment of waste water and air pollution, each processing unit 'solves' its own problems. An environmental study is required. | The flue gas treatment installed should clean the fumes to comply with Ghanaian environmental standards. Usibras features a modern gas cleaning system; Mim Cashew is using a basic system which is good enough for their case. |
| **Waste water** | Septic tanks are installed for treatment of waste water | Use of septic tanks or discharge to the ground | Use of septic tanks or discharge to the ground | Water is not in contact with product, in Usibras process. Settling tanks in Mim cashew. |
| **Interest** | Processors and institutions express a need for more information on CNSL, a business model on CNSL extraction and co-generation; there is interest in kernel oil pressing | Processors express need for local market on CNSL, a business model on CNSL and a joint solution on CNSL processing | Processing units are really open to get informed about the technologies (CNSL extraction, charcoal production) | Find local market for shell by-products, for small and medium scale plants. This includes gasification, CNSL marketing, shell cake, testa |

| Country | Guinea-Bissau | Kenya | Mozambique | Tanzania |
|---|---|---|---|---|
| **Installed capacity (2017)** | 12,950 MT/year | 15,000 MT/year | 76,100 MT/year | 40,500 MT/year |
| **Real quantity processed (2017)** | 5,950 MT | 3.500 MT | 56,100 MT | 12,200 MT |
| **Shells** | Shells are collected by a sugarcane liquor processor nearby, and mixed with sugarcane bagasse. The biomass feeds a steam engine, running a power generator (130 kW). | No CNSL production, but burning of shells (blended with other biomass) for thermal uses for industries; sales of shells at US$10/MT; experiences with co-generation, CDM projects | The only processor extracting CNSL is Condor caju, others are currently burning shells in open pits. INCAJU recently developed a composting technique adapted for shells; to produce commercial compost in the next months. | One example of artisanal CNSL extraction found; currently, not working.<br>Processors burn their shells in open pits |
| **Testa** | Burnt into boiler or disposed | At Kilifi, one buyer procuring testa for leather tanning | Burnt in open pits | Burnt in boiler or in open pits |
| **Rejected kernels** | Sold to poultry growers, or disposed | Disposal at 100% | Sold to poultry growers, or disposed | Sold to poultry growers, or disposed |
| **Smoke** | Shells are used as fuel<br>Basic smoke treatment (cyclone) installed in the biggest factories<br>Height of the chimneys is correct but fumes still are a nuisance to population in some cases.<br>Environmental laws are not enforced | Air pollution is reduced, because of blended combustibles for boilers.<br>An environmental study is required.<br>NEMA has worked out the norms and protocols of verification; verification is done by NEMA regularly | Shells are burnt in the boilers; smoke treatment is not installed in most cases.<br>Environmental authorities not enforcing existing regulations | Shells are burnt in the boilers; smoke treatment is not installed in most cases.<br>Environmental authorities not enforcing existing regulations |
| **Waste water** | Water is not in contact with product in the active factories; the rest don't have any particular water treatment system | Use of septic tanks or discharge to the ground | Use of septic tanks or discharge to the ground | Use of septic tanks or discharge to the ground |
| **Interest** | Techniques to reduce environmental impact and nuisances caused by fumes/burning.<br>Training on best practices to national cashew body & authorities<br>Re-launching power generation in Safim | Processing units are open to get informed about the technologies (H2CP, charcoal production, carbon emission reduction) | Work on joint solution for CNSL extraction<br>Appropriate technologies for smaller processors<br>Several institutions would like assessment on biomass power project from cashew shell<br>Training on best practices to national cashew body & authorities | Work on joint solution for CNSL extraction<br>Training on best practices to national cashew body & authorities |

### 2.6.2 Benin

In Benin, some good practices are applied at the factories. Fludor Benin has a 50 Mt/day CNSL extraction unit and procures, since July 2018 shells from the other factories. An installed clean heating system for thermal energy prevents air pollution.

On smaller level, the H2CP installations have been realized at the factories Kake-5 and Nad&Co. Also, Nad&Co possesses a small size CNSL expeller, of local manufacture with capacity around 100 kg per hour. The manufacturer quoted it at 1M CFA. The factory was using it for two years, but due to the tight balance, the operations were resumed. The other factories use shells for their boilers, provoking the exhausting fumes of incomplete combustion.

There is an intention to realize co-generation on base of shells and another biomass. There have been two studies. TechnoServe has recently completed detailed technical and financial feasibility studies on various capacities and models of power generation using cashew shell de-oiled cake. Based on attractive financials and detailed technical assessment with proven technology, BeninCajú is now working with investors to adapt and resource (financial and operational) investments for interested clients. BeninCajù, a TechnoServe project financed by USDA, is supporting cashew processing in Benin.

As of early 2018, seven cashew processing plants in the country produced over 14,000 MT of cashew shell as a byproduct, the majority of which has no use and is burned in open pits. This is not only a big economic loss for cashew industry but also having a negative impact on environment which will only grow as the processors expand production with support from BeninCajú. Cashew shell de-oiled cake is categorized as one of the best bio fuels, equivalent to lignite coal with a very high calorific value of ~4700 kcal/kg, well suited to generate thermal energy and electricity. Also, Nidetæ and IED conducted a feasibility study for Tolaro in 2018[xx].

Soon Benin will produce electricity from cashew shell; one investor is already working on the startup phase of 1.5 MW CHP plant. It involves an investment of $1.7 million with a payback period of less than 5 years, including an attractive IRR of ~37% based on realistic assumptions. The plant needs at least a quantity of 11.000 Mt de-oiled cake to run. This means a quantity of shells of 15,000 Mt/yr. This imposes a collection of shells from the different factories in Benin. This creates an opportunity for supplying factories to value their shells instead of incinerating them.

This investment will not only improve Benin cashew processing competitiveness by providing a market for cashew shell (a waste at present), but also improve environmental footprint of burning cashew waste in open pits and displacing diesel consumption – the primary source for on-site generators and grid power, resulting in a net carbon reduction. Rough calculations of $CO_2$ emission allowance (carbon trading) potential by avoiding open burning of shell is estimated at 7,912 tCO2eq less emissions yearly for capacity in reference which worth ~$107K.

If Benin were to process all cashews locally, the resulting byproduct could support producing 12 MW of electricity. Benin is an energy deficient country, only about one-third of Benin's population currently has access to electricity. The country produces less than 5% of the electricity it consumes, relying heavily on imports from neighboring countries who are themselves energy deficient[24]. Rapidly growing demand for power, estimated at 6 percent per year, has stressed the national grid.

The feasibility of cogeneration with regards to the current policies on energy production and supply is crucial.

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[24] Source: interview with TechnoServe, 2018, in coherence with the source https://energypedia.info/wiki/Benin_Energy_Situation

In Benin, CNSL has been used by the Electricity company to coat wooden electricity posts to protect them from borers.
For rejected kernels, it has been reported that Kake-5 was selling testa as cattle feed, in combination with 50% maize. For the rest there is 100% disposal of testa and rejected kernels. There is interest at the factories for kernel oil extraction.

### 2.6.3 Burkina Faso

In Burkina Faso there have been interesting developments with local technology. In addition to the CNSL processing at Anatrans (5,000 Mt RCN processed in 2017), there are further developments on the application of CNSL and use of shells for thermal energy:

1. Pyrolysis[25] with H2CP. The model was first installed in Gebana Afrique in 2011, and currently we account at least 6 pyrolizers only in the town of Bobo-Dioulasso. Others are also installed in small processing units out of Bobo, and in Benin. Currently, the technology is being disseminated in Côte d'Ivoire. Pyrolysers in Burkina are used both in cashew factories (up to 1,500 MT RCN/year) and in other agri-industries, the latter substituting firewood by their shells. Return on investment for the case of Gebana Afrique has been calculated to be 123 working days. Other technologies have been locally developed to allow a smokeless use of the shells in boiler, namely ISOMET's gasifier. One gasifier is installed at WOUOL. Lack of financial and technological support have led to bad use and understanding of the technology, which is currently abandoned.
2. As a more specific shells-to-charcoal solution, Anatrans, Away4Africa and 2iE[26] recently developed cashew shell charcoal and charcoal briquettes manufacturing technology; some small entrepreneurs are adopting the system. The charcoal from the retort reactor can be used as it is in the cookstoves, or densified in briquettes. One key factor in the charcoal production is choosing the site for charcoal making, so that it is not too far from the cashew unit, but also far enough from population to avoid complaints from bad smells or fumes.
3. Currently, the application of CNSL in industrial burners is being studied. CNSL is indeed a high-energy fuel, which can be classified in the category of heavy fuel oil. Mixed with a small amount of conventional fuel (diesel, DDO), it can be burned in oil burners without causing operational problems. In Burkina more, because of high fuel prices (521 CFA/L diesel, 488 CFA/L DDO), a significant portion of industrial burners is using used motor oil, which is a source of heavy metals in the air.

Similarly, a study on the use of the thermally degraded CNSL as a binder for road construction was made in 2017, with interesting results; but needs further R&D.

An in-line water treatment system was installed in Gebana Afrique some years ago, including settling tanks and phyto-filtration with vegetable species and cashew testa. This system enabled the factory to conduct the waste water directly to the river nearby, and reduced the frequency of emptying the septic tank.
Cashew processing units in Burkina generally do the most of their rotten and discarded kernels, by extracting the oil with a screw press, and mixing it with other agri-waste to make animal feed – sold in 80kg sacks, at CFA 3500. The oil is used by the units themselves as a substitute of castor oil for the shelling section. The two bigger units in Bobo-Dioulasso use the same expeller, thus incurring less investment costs. Kernel oil is sold at CFA 600 per liter.
Smaller units sell the discarded kernels to poultry and pig growers at an average price of CFA 150 per kg. Selected kernel bits are transformed into cashew butter (WOUOL), and candies.

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[25] See note 12, page 13.
[26] Institut International de l'Eau et de l'Environnement, a pan-African engineering school and Research center.

Composting of testa alone and in mixture with other local substrates has been tested, with satisfactory results, but currently no factory has adopted the technique. Details on the techniques and guidance on compost production can be obtained through the consultants.

#### 2.6.4 Côte d'Ivoire

In the case of Côte d'Ivoire, processing capacity is increasing. The concentration of processing in hubs, which is the sector strategy will enhance the opportunity for by-product processing. There are 4 hubs identified. Bouaké is the first hub, with OLAM as the main processor. OLAM has been processing CNSL for years. However, there are relatively few initiatives in by-product development.

In Abidjan, Cilagri has started a 100,000 Mt/year processing factory and is planning a co-generation unit. In general, there is a general interest in the technologies of pyrolysis for thermal energy and charcoal production.
The project Agrovalor "Valorisation énergétique de déchets agroindustriels en RCI" is implemented by Nitidæ[27] from 2017 to 2020, and one of the activities is to install 8 H2CP pyrolizers for 8 different agri-processors.

Processors have generally taken measures for basic waste water treatment. Other technologies for waste management and by-product processing are not practiced by processors; shells are generally incinerated or evacuated. CIAPOL is regularly visiting the factories on compliance with environmental regulations, risks and mitigation measures. Currently, nearly all factories dispose the shells to specific waste disposal sites, through a system of agreed waste collectors. These companies collect the waste against a fee of 2,000 FCFA/Mt of shells.

For rejected kernels and testa, most factories dispose them. Rotten and discarded kernels have a market locally, for chicken and pork feed. The discarded bits are sold to growers at CFA 60 to 100 per kg.

[27] Nitidæ is the new entity created by the fusion of RONGEAD and ETC Terra

### 2.6.5 Ghana

Affected by the lack of protective regulation of the cashew industry, Ghana saw most of its factories close down in the 2016-2017 period. In 2017, only Usibras and Mim Cashew were still running, but with reduced volumes.

The process at Usibras is unique in Africa, as it is a Brazilian technology. It is based on the oil bath roasting of the nuts. Thus, CNSL is recovered in the roasting step. After shelling, the spent shells still contain appreciable quantities of oil (oil bath process is assumed to remove only 50% of the oil content of the shell). According to Usibras[28], some shells are used in the factory boiler, and the rest are sold to another factory nearby, having a biomass boiler.

At Mim Cashew, the reduced processed volumes resulted in the stoppage of CNSL extraction operations. In 2018, the activity increased and the factory has been able to run the plant, during several weeks, to process the shells from this and last year.

CNSL from Usibras is mainly sold on export, with small volumes being reported to be sold locally, though no more details on the buyers' profile are available. CNSL from Mim Cashew is completely sold ~~100%~~ on international market.

Usibras burns the testa in the boiler. Compliance with the legal emission thresholds is attained due to a modern gas filtering system, including in-line filters. Mim Cashew has also installed a cyclone and a scrubber to eliminate particulate matter in the gases, though it is only running with one of the two boilers.

On waste water management, Usibras method does not apply water directly to the product so there is no source of phenols in water, apart from water used in cleaning. The factory has installed a biological and anaerobic treatment system. The resulting water is sprayed on the lawn of the factory. Mim Cashew is using decantation tanks and releasing the overflowing water to the environment.

The area around Wenchi used to gather several small-scale processing units. The resulting shells have been reported to be used as fuel for pottery making.

[28] Interview with Usibras, May 2, 2018

### 2.6.6 Guinea-Bissau

After many years of having only a small and weak processing sector, in the recent years two new companies started operations and have been operating steadily, working with a mechanized system. The first one is Arrey Africa, in Bula, which is the second in Africa working on Brazilian technology. Arrey is not using steam in the process, but brick furnaces directly heating CNSL circulating in pipes. The hot oil circulates to the cooking drum, where it gets in contact with the nuts. When nuts are heated up, they swell some CNSL, so the overflow oil is recovered in a tank; and sold for export. The chimney of the ovens is equipped with a cyclone and a CNSL condensing system.

The waste shells still contain some oil, and up to 40% of them are used in the factory to run the furnaces[29]. The rest is recovered by a distillery nearby (Noba Sabi) for its biomass boiler.

The second processing unit is West African Cashew, from Grupo Santy, in Bissau. Santy started in 2017, using state-of-the-art processing equipment. The cooking step is using steam but, as the manager stated[30], the steam is not released directly to the nuts. Thus, water does not get in contact with the product except for cleaning purposes. Water is conducted to underground septic tanks. Some waste shells are used in the boiler, and the rest are sent to Noba Sabi distillery.

Interestingly, the factory of Noba Sabi is using the shells mixed with sugarcane bagasse in a biomass boiler (steam rating 4 MT/hour). The boiler produces superheated steam at 16 bars, that is injected in a steam machine, and generating electricity with it. The generator is only 130 kW (110 kW neat) so power is entirely consumed by the factory. It must be stated that primarily this equipment was intended to be installed at Bolama (20km South from Bissau, through the sea) at the Licaju cashew processing unit, but the beneficiary never accepted the machines and they stayed at the port for years; in the end, Noba Sabi could recover them and install by themselves.

Both cashew processors state that all the excess shells is recovered by Noba Sabi, meaning that in 2017 around 2200 MT shells would have been used in the boiler; however, biomass needs to run the factory have been estimated at 1200 to 1500 MT per year - considering a high availability rate of the machine, which is not the case, as the owner of Noba Sabi[31] reported frequent maintenance issues with the machine. Considering that sugarcane bagasse is used also to feed the boiler, real consumption of cashew shells must be remarkably smaller than reported. With increasing cashew processed volumes, in 2018 there will be a surplus of shells to be disposed off via the available municipal services.

There are two additional steam machines which used to run on cashew shell in Guinea-Bissau. They were all installed via a credit line from the World Bank. One of them was installed at SICAJU cashew processing plant, in Bissau. The generator (Benecke) can produce up to 54kW (70kVA), but it has been recorded that maximum power needs of the plant were not more than 30 or 40 kVA. SICAJU is a cashew processing center having all the processing steps, although it was designed to host the CPC (Centro de Processamento do Caju), a Cashew processing development center and school, working mainly with cashews unshelled at satellite units around. This was the development scheme for the cashew industry between years 2017-2012; unfortunately, the supporting efforts from the government were not able to keep this small industry running, and the center shut off operations in 2009; but restarted in several moments, depending on the support received, or commands from some smaller processors. It is currently working intermittently, with small production loads for local market. Since the stop of the steam machine in 2009, it was never run again. However, the equipment seems to be in a good state. The center was visited by a bioenergy expert in 2017, in the frame of an ECREEE[32] mission (GEF funded) who quoted the needs for maintenance to restart the generation system at around EUR 15,000[xxi]. It must be said that the interviewed person at SICAJU[33] mentioned the generation of thick fumes from the boiler as an inconvenient issue, and people living

[29] Visit to Arrey África on August 18, 2018
[30] Visit to WAC - Santy on August 17,2018
[31] Visit to Noba Sabi and interview with the factory manager on August 20, 2018
[32] Ecowas Center for Renewable Energy and Energy Efficiency
[33] Visited on August 22, 2018.

in the vicinities complain recurrently. The height of the chimney seems correct, but a gas cleaning system could be added upstream anyway.

*Figure 11. Sicaju plant (outside), the biomass boiler, and the steam machine*

The third steam machine was installed in Safim, about 10 km from Bissau. It was run by Agrosafim, the company running the micro-grid in Safim area[34]. Gross generator output would be around 54 kWe, and deducting parasitic consumption the net power would be 42 kW. According to the ECREEE report, the system only worked during the test phase in 2013, as several operational problems were encountered, relative to frequent chocking of the boiler grate and excessive production of fumes, probably due to an incorrect operation of the boiler. Apparently, the technology adopted was not

[34] Power generation in Guinea-Bissau relies mainly on diesel generators. The electricity grid is highly decentralized, and divided into several independent grids. The company operating most of the mini-grids is state-owned, but some, as in Safim, depend on private companies.

the model that was primarily proposed by FUNDEI[35] – a steam machine, but finally a steam turbine was selected. Agrosafim never wanted to run again the plant, and any public entity has forced the company to do so. The plant has been stopped for five years now. Anyway, maintenance costs for a small steam turbine are considered much higher than the case of the steam machine. Also, while efficiency of the system is lower than in Sicaju. In addition, investment costs for the turbine machinery were much higher. Finally, transport costs of the shells fuel should be considered, thus driving energy generation costs higher and making the model less appealing.

*Figure 12. Biomass power plant at Safim (left). Photo of the boiler (right)*

There is a CNSL extraction plant, of Portuguese make, installed at the Noba Sabi distillery. The owner ran it for some time but decided to stop several years ago, because of lack of a good market for the oil. It must be said that he did not show any interest in extracting again the oil, neither a specific knowledge on cashew shell processing and/or CNSL quality criteria.

No uses of cashew testa have been reported in Guinea-Bissau.

Discarded kernels are said to be sold to chicken farmers. Also, some local pastries are made with unwanted kernels.

[35] Fundação Guinense para o Desenvolvimento Empresarial Industrial

### 2.6.7 Kenya

The cashew sector in Kenya is characterized by concerns about its RCN supply. Cashew production mainly takes place at the coastal area. The production is decreasing as there are hardly any investment plans in production. Quality of nut is low (KOR of 44). Production estimations from different parties for the 2018 crop were evaluated at 12,000 Mt of RCN[xxii].

However, the industrial capacity has increased to 15,000 Mt of RCN. The priority of every processor is to ensure reliable supply. On the coastal side, besides the two bigger processors, there has been up to 40 smaller processors around. The bigger processors near Nairobi (in Thika and Murangu) source also from the coastal areas. Although there is an export ban on RCN, quantities disappear through the porous borders to Tanzania, from where export to Asia is done. All these results in harsh competition for RCN by processors; underutilization of the cashew processing facilities and a sector climate where competition rules over collaboration.

Cashew processing facilities in Kenya make part of a good investment climate. For example, in Thika, the cashew shells are sold to other industrial facilities with boilers. Often, cashew shells are mixed with other biomass, like macadamia shells – to reduce the concentration of CNSL exhaust fumes. The proximity and the possibility to mix up with other huge quantities of biomass make that the cashew processing facilities not to encounter challenges in the disposal of cashew shells. Each processing factory has bilateral relations with the clients for shells and the issue is not centralized in the sector as a major issue to be addressed.

As a result, further by-product value addition is not one of the priorities of processors: there is no CNSL extraction, charcoal production or co-generation from the cashew shells. Collaboration could lead to one of these options, but exchanges between processors are limited. This perception was confirmed by bilateral exchanges with the processors. The issue of by-products must be seen in this perspective. However, the non-awareness of the unexploited potential and value addition from the shells is an issue to be addressed, according to the actors themselves. The processors were not oriented to contribute to green energy and carbon emission reductions from the cashew shells.

Overall, there have been investments and there is willingness by individual processors to improve the environmental behavior: investments in improved exhaust fumes and waste water treatment.

### 2.6.8 Mozambique

Several medium and big scale processors are present in Mozambique. Most of them are located around the axis Nampula-Nacala, in the Northern part of the country; another pole is located around Gaza, just North of Maputo.

Average RCN processed volumes, per factory, were as high as 5,000 MT RCN in 2017. This means that there is potential for CNSL extraction. However, only Condor Nuts is extracting CNSL. The unit has been reported to encounter operational problems (some related also to marketing of CNSL) for several years, and recently benefitted from financial support from the MozaCaju project to start running in a continuous basis. Nowadays, the factory manager affirms to be satisfied with the system, and getting benefits from the sale of CNSL. Shell cake is sold away as a cooking fuel, as the factory has developed an improved cookstove that is fueled with it. These stoves have been provided to the staff in the factory, as a credit. The Condor group is running two cashew processing units around the Nacala zone, and constructing a new one in the Southern part of the country. The manager states having the ambition to install CNSL extraction systems in the rest of the factories of the group, but this is subject to a sufficiently good environment to secure the investment – as RCN prices are rather volatile, processors are cautious regarding some new investments.
Some quantities of CNSL are sold in the local market, in Nampula, as protective oil for wood (the 5-liter bottle costs 230 Mt – price per liter is equivalent to US$0.76).

INCAJU has developed a technique to compost shell – see details in Section 2.2.2, point 6.

### 2.6.9 Tanzania

The cashew processing sector in Tanzania is not having its best days, though the price stabilization experienced this year has shed some good perspectives for the years to come, in the processing sector. The cashew processing zone is in the Southern part of the country, on the stretch from Mtwara and Ruvuma. Several processing units are installed in the industrial zone of the coastal town of Mtwara; together, the processing capacities account for more than 10,000 MT, and according to interviewed authorities, volumes should increase in the next years. SBS, a waste management company, is having its facilities in the industrial zone and is currently planning to launch a power generation project that would include CNSL recovery.

However, CNSL extraction has surprisingly been running for years. A local entrepreneur started about 10 years ago to extract CNSL through a rudimentary method: burning the shells in an open pit, equipped with some pipes in the floor which recover the leaked fluid. Due to shell combustion in an open space, big quantities of black smoke are produced, and therefore the entrepreneur located his activities in a zone far from any human settlement. Even if the CNSL quality and the process efficiency could not be compared with that obtained through “conventional” methods, the oil had been sold on export at US$500/MT, then as furnace oil to the steel factories in Dar es Salaam, far from Mtwara. When international oil prices dramatically decreased, the market for local CNSL also reduced drastically and eventually disappeared. Still some people buy small quantities of this CNSL to protect wood against borers.

*Figure 13. CNSL extraction activities in open air around Mtwara, Tanzania*

## 2.7 Comparison with African context and practices

African processing sector has variety of contexts and processing methods. It is therefore difficult to provide recommendations to reflect the whole African cashew processing industry. However, some ideas can be highlighted as principles to develop:

- Regarding value addition of the solid waste (by-products), shells are priority because of the polluting and economic potential. If CNSL were extracted from all the shells, no more factories would emit these cashew-characteristic fumes. If the shells don't find a market, processors will still use them as fuel. Units using the steaming process, and burning the shell directly to fire the boiler are polluting more than in those burning roasted shells – as roasted shells (roasting and hot oil process) only have 50% of the original CNSL content;
- Using steam as heat carrier in the process, i.e. using a boiler to feed both cooking and drying process, reduces pollution, provided that the boiler is fed with de-oiled cake. Most African processors adopted the steaming method, so they are already well placed compared to the Indians.
- The opportunity to process T-CNSL into cardanol and residol. Proven technology exists, and there is international market for cardanol. Regarding residol, the market for local applications must be identified by country; but perspectives are promising, as some industries exist that would be able to introduce residol in their process: tyre & rubber, paint & coating, construction; without forgetting that residol can also find use as a fuel, thus becoming a local source of energy for the countries.
- All waste management technologies are proven and at commercial scale. The blocking points for the adoption of the waste management technologies in Africa can be:
    - Lack of knowledge about the waste management solutions
    - Lack of market for the by-products
    - Limited investment capacity
    - Lack of institutional support for promotion of the solutions
    - Lack of regulative legal frames on environment

# 3 Assessment of institutional policies and stakeholders

This section of the study assesses the current and proposed policy, legal and institutional framework governing the sector including identification of institutional and legislative gaps, and an assessment of existing institutional and human resource capacity to manage the identified environmental and social opportunities and risks.

## 3.1 Policy, Legal and Regulatory Framework

Generally, there is no specific policy on cashew by products and cashew environmental waste existing in the various countries, but we identified relevant policies, legal and regulatory frameworks, related to environment, energy and carbon emissions.

### 3.1.1 Environmental Code and regulatory bodies

Some relevant policies that regulate industrial waste, including their regulating bodies are under the responsibility of the Ministry of Environment. In each country an Environmental Code exists, stipulating the necessity of an Environmental Impact Study before investing in and operating any of processing activities.
The Environmental Code, the Environmental Studies are oriented towards compliance on the environmental standards. These standards are often limited to qualitative indications.
This institutional framework, the legislations on Environmental Studies are very similar in the African countries. They require an Environmental Impact Assessment for the processing units, including an environmental and social risk assessment and mitigation plan. The Environmental Codes stipulate the responsibilities of the bodies who inspect the implementation. Specifically, per country an analysis of the main implications of the legislative texts is done.

*Table 20. Overview of the Legislation texts per country*

| Country | Legislation | Main implications for cashew by-product |
|---|---|---|
| **Benin** | • Loi-cadre sur l'environnement publique du Bénin (loi 98-030, 1999) - Articles 88, 89, 91<br>• Décret N°2015-382 du 09 juillet 2015 portant organisation des procédures d'étude d'impact sur l'environnement - Articles 3, 4, 5, 6, 7, 8, 10, 11, 14, 15, 16 | Environmental standards on soil water and air are indicated in general terms. Compliance with environmental standards for initiated projects are under coordination of the Agence Béninoise pour l'Environnement (ABE). Procedures are well described and online available[xxiii]. |
| **Burkina Faso** | • Loi N°006-2013/AN portant Code de l'environnement au Burkina Faso<br>• Décret N° 2015-1200/PRES-TRANS/PM/MERH/MME/MICA/MS/MIDT/MCT portant modalités de réalisation de l'audit environnemental<br>• Décret N°2001-342/PRES/PM/MEE du 17 juillet 2001 portant champ d'application, contenu et procédure de l'étude et de la notice d'impact sur l'environnement | Public services are supposed to take measures to reuse waste (art. 50)<br>The existence of the *Fonds d'intervention pour l'environnement* for the public services (art. 16)<br>Environmental audit to be completed every 3 or 5 years<br>Upon assessment by competent authorities, the processing activity is subjected to Notice d'impact (complete) or Étude d'impact |

| | | |
|---|---|---|
| | • Décret nº 2001-185/PRES/PM/MEE portant fixation des normes de rejets de polluants dans l'air, l'eau et le sol | (simplified) |
| **Côte d'Ivoire** | • Loi n° 96-766 du 3 octobre 1996 portant Code de l'Environnement<br>• Décret n° 96-894 du 8 novembre 1996 EIE RCI | The need of an environmental impact assessment guided by Agence Nationale de Développement de l'Environnement (ANDE), upon announcement of project. Le Centre Ivoirien Antipollution (CIAPOL) is the governmental body to assess compliance on the environmental standards. |
| **Ghana** | • Environmental Protection Agency Act, 1994<br>• Environmental Assessment Regulations, 1999<br>• Sector specific effluent Quality parameters (ANKOBEN, EPA) | EPA is the body coordinating he activities of the relevant bodies for the purposes of controlling the generation, treatment, storage, transportation and disposal of industrial waste<br>Different conditions apply for issuing Environmental Permits, (EIR or EIS) depending on the activity being classed as small, medium or big scale.<br>Environmental Management Plan every 3 years |
| **Guinea-Bissau** | • Lei nº 10-2010, Lei sobre Avaliação ambiental<br>• Lei nº 1-2011, Lei de Bases do ambiente | The need of an environmental impact assessment for any new intervention is to be determined by CAIA, upon announcement of project. Detailed, simplified or no need of impact assessment report, depending on preliminary evaluation by CAIA.<br>No specific regulations on air/water/soil pollution |
| **Kenya** | • Environmental Act (1999)[xxiv]<br>• Legal notices including regulations and specifications on air pollution disposal (Legal notice no. 34), waste water and waste disposal (Legal notice no. 121) | NEMA, as a central responsible governmental body is not only assessing environmental impact assessments and monitoring the compliance, but is also the coordinating body of the CLIMATE CHANGE ACT and the CDM projects |
| **Mozambique** | • Lei nº20/97 Lei do ambiente<br>• Decreto nº 54/2015 de Regulamento sobre o Processo de Avaliação do impacto Ambiental | Cashew processing units are classed "Category B", thus subject to EAS (*Estudo Ambiental Simplificado*, |

| | | |
|---|---|---|
| | • Decreto nº 18/2004 de Regulamento sobre Padrões de Qualidade Ambiental e de Emissão de Efluentes, modified by Decreto nº67/2010<br>• Decreto 83/2014 de Regolamento da gestão de resíduos perigosos | Simplified Environmental Study) 40% of the environmental taxes is injected into the Fundo do Ambiente[36] (FUNAB) |
| **Tanzania** | • Environmental Management Act, 2004<br>• Environmental Management (Fee and Charges) regulations, 2008 (amendment 2016)<br>• Environmental Management (Air Quality Standards) Regulations, 2007<br>• The water resources management Act, 2009<br>• TZS 860:2005 Tolerance Limits for Municipal and Industrial Wastewater<br>• TZS 845:2005 Air Quality – Specification | Cashew nut processing is subject to Environmental Monitoring and audit annually |

### 3.1.2 Renewable energy policy

All the 8 African countries face an increasing gap between the demand and supply of (electrical) energy in country. With the demographic growth and the increasing economic activities, electricity demand will increase for the coming decades. Conventional systems of electrical energy production, transport and distribution face enormous challenges, particularly when it remains under a centralized, government owned structure. Generally, governments started to liberalize the energy sector by privatization and adopting legislation for energy production and supply by the private sector. However, the transition is not always completely done, leaving private actor initiatives for investments with uncertain assumption. Particularly, the lack of legislation, procedures and commitments on the supply of electricity to the grids is an issue. Per country the situation is summarized, as this is a crucial issue regarding the co-generation opportunity.

Another policy framework is the regulation on renewable energy. These policies are in an early stage of development. A recent trend is the creation of specific governmental energy agencies with attributions of policy development, regulations and linking with (inter)national programs on renewable energy

To illustrate the actual need for regulations, one of the interviewed actors pledged: *"Obviously the cost/benefit will vary based on specific inputs per country (relative electricity costs, etc) but significantly less than 1MW the economics look much less attractive, unless you scale way down to very limited power needs (~80-100kW) for limited use. 24-hour power needs are a big factor; starting up at 1MW generator each day for 8 hours is inefficient versus running 24hrs. If there is a clear policy and reasonably reliable payment or cost reduction from the utility then grid feed-in might work (this seems more plausible working with a private power supplier versus state-run). The first big step for ACA lobbying efforts would be an official law or written policy of feed-in tariffs."*[37]

### 3.1.3 Carbon emission reductions

Another regulatory framework is related to the carbon emissions. All countries have developed a climate mitigation and adaptation policy with funding from the UNFCCC through the Global Environment Facility (GEF), since the Paris Climate Agreement in 2015. Each of the adhering countries to the Agreement, has developed an Intended Nationally Determined Contributions (INDC)

[36] Environment Fund

[37] Interview TechnoServe, Benin, May 2018

plan. These plans state in headlines the commitments and actions on GHG emission reduction towards 2030.
The carbon emissions of the African countries are presented by the International Energy Agency (IEA), where figures from 1975 to 2016 of 6 of the countries are found. The increase of the last decades indicates a total of about 60 million of tCO2-eq of carbon emissions. Nevertheless, extrapolation of the global increasing trend on GHG emissions (from 1975 to 2016) indicates increasing GHG emissions for the next decades by the African countries on basis of a couple of assumptions: the demand for energy will increase due to (1) the increasing population and (2) the rising economies. This emphasizes the importance of substitution of conventional (fossil) energy sources, by available waste. Cashew waste constitutes an opportunity for the countries to take.
Moreover, Clean Development Mechanisms (CDM) and the concrete example of the MCC intervention in Benin provide the frameworks for the development of renewable energy investments and projects.

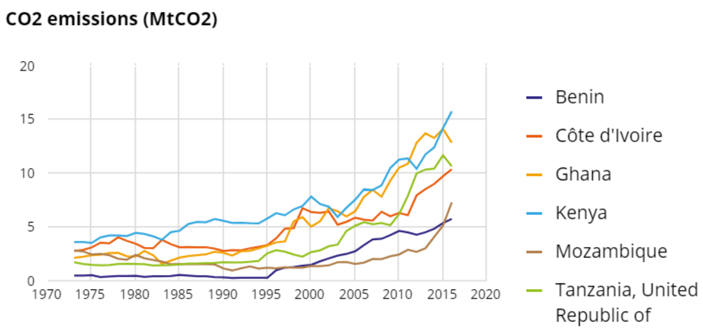


*Figure 14. Development of $CO_2$ emissions (in MtCO2eq) of 6 selected countries (Source: IEA Energy Atlas)[xxv] Note: no figures available for Burkina Faso and Guinea-Bissau*

The CO2 fixation of the cashew trees is not taken into account in the analysis of the carbon emission reduction and carbon offset. Although for the cashew sector, this presents an interesting option as well. Integrated climate change interventions on cashew production and processing of by-products can be developed within the CDM frameworks.

### 3.1.4 Specific institutional environmental policy per country

#### *3.1.4.1 Benin*

*Investments in the Energy sector*

MCC has a Benin Power Compact[xxvi]. MCC is partnering with Benin through a $375 million compact, designed to modernize the West African country's power sector. The compact, which is supplemented by a US$28 million contribution from the Government of Benin, aims to strengthen the national power company, attract private sector investment, and fund infrastructure investments in electric generation and distribution as well as off-grid electrification for poor and unserved households. An amount of US$132 million will be used to increase Benin's domestic generation capacity up to 46 MW. The examples mentioned are hydro and solar. Co-generation is not mentioned. The co-generation aligns with the policy of the increase of the electrical power generation in the country. The connection with the grid is still a difficult issue. The MCC has included in its Benin Power Compact[xxvii] a policy reform and institutional strengthening project. MCC funding is used to support interventions to improve governance in the electricity sector by improving regulation, establishing a tariff policy, planning periodic tariff adjustments, increasing energy efficiency, and strengthening the policy and institutional framework for independent power producers.

The agency in Benin in charge of the reform of policies, regulations and institutions is ARE[38]. The agency enhances a favorable environment for independent energy production, via the implementation of a legal framework, contracts, credit reimbursement mechanisms[xxviii]. There has been contact with the Unité chargée de la Politique de développement des énergies renouvelables (UC-PDER), but they also say that the policy on net metering is still in progress.
For Benin, different activities are planned to reduce GHG emissions towards 2030, according to the Contributions prévues déterminées au niveau national (CPDN), Bénin[xxix]. One of the elements is the use of agri waste biomass as energy source, substituting conventional (fossil) fuels. This constitutes an opportunity for the cashew sector.

*Farmers' demand for nutrient compensation*

A few stakeholders expressed the need for the role of cashew waste (biochar) in contributing to soil health.
According to FENAPAB, harvesting of cashew nut means also evacuation of nutrition elements from the farm. The soil must be enriched to keep the nutrition balance on soil fertility. The idea is that the shell, in the form of biochar, should be brought back to the farms.
The CNTC (Comité National des Transformateurs de Cajou) has also its regards to biochar as solution.

[38] Autorité de Régulation de l'Electricité

#### 3.1.4.2 Burkina Faso

One of the interesting applications of the Environmental Code is the Intervention Fund for the Environment (FIE), created by the Code de l'environnement, 2013. This is a fund that comes in the form of calls for annual projects, and provides funding to any group or entity, public and private, with an interventional project ~~or~~ to improve~~ment~~ upon the sustainability of the environment. This fund is fed by environmental taxes at national level, plus a participation of the Government, and inputs from donors such as development organizations. The FIE provides five fields for ~~of~~ application: Forest management, conservation, timber forest products, non-timber forest products, and climate change. Waste from the food industry uneasily being classified into one of these categories, it is logical to observe that no project on management and recovery of waste cashew has been retained. The Minister of Environment recently left the door open to extending the Fund's fields of action, but this is subject to support from donors.

Another recent step in Burkinabe legislation was made in 2017, when Law No. 014-2017/AN on general regulations on the electric power sector was adopted. This law is supposed to facilitate the generation of energy from renewable sources by private actors, the purchase of electricity produced by these actors, and the creation of electric micro-grids. For the moment, it has not been developed. Two agencies are created, the ABER[39], in charge of the promotion of rural electrification, and the ANEREE[40], on renewable energies. However, the text gives two years for the related legislation - like feed-in tariffs, mission and resources of the Agencies, modalities of the Independent Power Producers - to be defined and come into force. For the moment, these decrees have still not been issued, although in the practice, several Independent Power Producers (solar PV and one biogas) are registered before the creation of the Law in 2017.

Activities planned to reduce GHG emissions towards 2030 in ~~For~~ Burkina Faso (ref. Contributions prévues déterminées au niveau national (CPDN), Burkina Faso[xxx]) include the promotion of local waste biomass as fuel for households. Indeed, firewood and wood charcoal are an important energy resource in Burkina, and feature as an important part of non-renewable exploitation. This can be partially tackled by the substitution with residual dry biomass, such as cashew shell.

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39 Agence Burkinabè de l'Électrification Rurale

40 Agence Nationale des Énergies Renouvelables et de l'Efficacité Énergétique

#### 3.1.4.3 Côte d'Ivoire

Côte d'Ivoire formulated in their « UNFCCC GEF Contributions prévues déterminées au niveau national de la Côte d'ivoire »[xxxi], different carbon reduction activities up till 2020. The country has made the commitment to reduce carbon emissions by 28% in 2030, compared to the Business As Usual scenario. Some principal actions that are relevant for the value addition of cashew by products and are related to renewable energy, are amongst others:

- To promote alternatives for charcoal by value addition of agricultural biomass
- For the industries: Energetic audit and the evaluation of the potential to substitute or optimize (e.g. by co-generation by use of biomass)
- On institutional level: policy on incentives for the development of renewable energies and the creation of an Agence de Promotion des Energies Renouvelables
- Waste biomass and circular economy: recycling and re-use of agricultural by-products

This constitutes an opportunity for initiatives to use cashew waste as energy source. Moreover, Côte d'Ivoire is a GEF beneficiary and has made voluntary donor contributions to the institution's replenishments spanning the pilot phase through the third phase, for a total of USD 14 million. The country recently committed to paying its outstanding contributions and has taken the necessary steps to honor these commitments.

The country has been the beneficiary of projects in the various GEF focal areas: 55 medium and large projects and 299 microprojects totaling US$299,179,625 in GEF subsidies; the addition of co-financing brings this amount to over US$ 1,145,046,268 in total gains. In addition to projects, GEF has created an Institutional Framework, namely the GEF National Commission (CNFEM), which was established by Decree No. 2012-162 of February 9, 2012. This Commission provides a framework for discussing and coordinating GEF activities in Côte d'Ivoire, and is chaired by the Ministry of Economy and Finance. The functioning of this Commission is the responsibility of a Technical Committee that is chaired by the Ministry of Environment – the main beneficiary of GEF funding – and a Permanent Secretariat, our GEF Operational Focal Point responsible for the administrative management and coordination of GEF activities in the country. The CNFEM receives funding from the State for its activities. To conclude, Côte d'Ivoire would like the financing of the projects and programs outlined in its road map to be considered. The road map was drafted after the country committed to adhering to the decisions reached by the international community during COP21 and considers the priorities set forth in Côte d'Ivoire's National Development Plan (NDP 2016-2020)[xxxii].

#### 3.1.4.4 Ghana

Legislation in Ghana is, in general terms, more elaborated than its neighbors. For example, Ghana has already issued the National Renewable Energy Act, and set up a feed-in tariff for renewable power production. Ghana's INDC[xxxiii] features promotion of bioenergy, and the generation of a National bioenergy Strategy as a tool. Several power production agreements have already been signed in Ghana (Safi Sana's biogas in Ashaiman[xxxiv], Genser's cogeneration in Chirano mine[xxxv]).

The authority responsible for environmental control processes of industrial units is the Environmental Protection Agency (EPA) – The department in charge enforces and conducts regular inspections at factory sites. Environmental permits shall be renewed every 3 years, including Environmental Management plans for mitigation; which are reviewed by EPA. As stated by the agents interviewed[41], strict control is only applied to medium and big processors. Small cashew processors are considered as having a minor impact on environment.

In 2012, the National Clean Production Center Ghana was created, under EPA's management. Its mission is to assess the productive sector in Ghana to become more efficient. Resources efficiency is tackled from an industrial symbiosis approach. NCPCG has been active in many waste-to-energy realizations throughout the country, such as the promotion of biomass boilers in big industries.

Ghana aims to reduce greenhouse gas emissions by 15 percent by 2030. Actions include improvement in energy efficiency of industrial facilities, replacement of light crude oil with natural gas in electricity generation plants and the reforestation and afforestation of 10,000 hectares of degraded lands annually[xxxvi].

[41] Interview with EPA Ghana, May 3, 2018. Carl Fiati and Juliana Boateng

#### *3.1.4.5 Guinea-Bissau*

Environmental laws exist in Guinea-Bissau only since 2010, if the Forestry law (Lei Forestal, 1991) is not to be considered. The first to be created was the Environmental Assessment law. The competent authority for Environmental assessment purposes is CAIA[42]. According to the laws, no new use of land should be given without an Environmental assessment via CAIA. Specifically, industrial units should prepare an Environmental Impact Study report. However, in practice all public and private parties encountered agree that these precepts are not often applied.

The National Environmental Act, Lei de Base do ambiente nº1/2011, stipulates that special regulations should be announced on polluting effluents discharged to water. The same general declaration applies to air pollutants. To now, specific texts were not found. Regarding solid waste, the law foresees its use as a source of energy, provided that any toxic substance arising from that conversion is not emitted to the environment. In any case, the responsibility of waste management lays on the person generating the waste. The text talks about discharge and dumping, saying that only “competent entities” would determine the eligible sites for the discharge. Conditions for this waste discharge shall respect a permit.

According to the representative person in the Ministry of Industry and Energy[43], laws to promote a higher share of renewables are being elaborated. A law on renewable energies has been drafted since 2011, but not yet adopted. However, the National Action Plan on Renewable Energies 2015-2030 exists – and mentions the energy potential of cashew shells. Despite not having a regulatory frame for renewable energy, the country is promoting small and micro-scale power generation projects, mainly in peri-urban areas and related to solar photovoltaics.

Under the GEF fund, the project called “Promoting investments in small to medium scale renewable energy technologies in the electricity sector” addresses the existing energy challenges of Guinea-Bissau by promoting renewable energy investments in the electricity sector. This includes a capacity building component on Renewable energies, and support on development of a National Renewable Energy Action Plan. In the latter, 25% of the peak power would be provided by renewables by 2020, and 50% by 2030. Following Guinea-Bissau’s experiences in power generation from biomass, the strategic investment plans consider cashew shell as an energy source for small-scale power production; the plans mainly aim at installing again a power generator from cashew shell at Licaju, increasing power generation capacity to 250kW at Noba Sabi, and installing a gasifier to run in duo-fuel at Arrey. These projects are seeking funding, and are summarized in the Investment plans[xxxvii], which were presented in an investment workshop in May this year[xxxviii]. Other biomass power generation projects on micro power generation from biomass such as bagasse combustion and biodigester in the Investment plan are those featured in the recommended projects summarized in the ECREEE report (see final note, xxi).

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[42] Célula de Avaliação do Impacto ambiental

[43] Mr Júlio António Raul, interviewed on August 23, 2018

#### 3.1.4.6 Kenya

On institutional level, the NEMA is responsible for the regulations, the implementation and the audit of compliance to the standards: the Environmental Act (EMCA1999). Detailed regulations on waste, air pollution and waste water are applied. These regulations are detailed and specific, although not specific for cashew processors. Compliance to these regulations is assessed on a yearly basis under responsibility of NEMA.

NEMA is also responsible for the Climate Change Act, which stipulates the climate change duties of the private and public sector. Through NEMA the Climate Change Fund is managed and Kenya has up to 40 CDM projects approved. However, in the cashew sector there is not yet awareness of the opportunity of CDM.

Kenya has even a policy on co-generation and Feed In Tariff[xxxix]. Kenya has several co-generation power plants, among all a 40 MW Bagasse Based Cogeneration at West Kenya Sugar Limited[xl].

The question is: with the unreliable supply and the lack of expected increased production the coming years[44], the investments in the cashew processing sector are esteemed not to be much, and to a less extent on by-product processing. However, small scale solutions are still at the interest of processors. We observed:

- Interest in the installation of the H2CP pyrolizer
- Interest in the low investment charcoal making (with the priority to provide it as an opportunity for the RCN suppliers, so that farm-firm linkages would be enhanced
- Interest in the carbon footprint assessment

Kenya's Intended Nationally Determined Contribution[xli] (INDC) commits to reducing GHG emissions by 30% (143 MtCO2eq) relative to business as usual levels by 2030, contingent on receiving international finance, investment, technology development and transfer, and capacity-building support. The INDC notes that Kenya will build upon the National Climate Change Action Plan (NCCAP) actions through (1) expansion of geothermal, solar, and wind energy production, (2) enhancement of energy and resource efficiency, (3) progress towards achieving tree cover of at least 10% of Kenya's land area, (4) increased use of clean energy technologies to reduce over reliance on wood fuels, (5) adoption of low carbon and efficient transport, (6) use of CSA in line with the National CSA Framework, and (7) improved waste management (e.g., waste recycling, landfill gas management).[xlii]

[44] Source: several interviews revealed that there plantations are ageing and there is hardly any new planting scheme.

#### 3.1.4.7 Mozambique

The environmental law in Mozambique states the Government's responsibility is to define the environmental quality parameters, and also to define the adequate processes to retain or neutralize polluting agents. As the law acts, it is also the Government's responsibility to create economic incentives, with the aim to encourage the use of environmentally safe technologies and processes.

On renewable energies, the country has set an ambitious electrification plan to achieve 100% access to electricity in 2030. The inclusion of new power production sites is considered, but also the creation of mini-grids when an extension of the national grid is not economically viable. Access to electricity has been reported as a priority for government[45], so new projects for electricity generation in this context would be welcome and even benefit from special support by the administrative bodies. More specifically, a study on renewable energy potential including biomass the whole country has been submitted[xliii] – where, paradoxically, cashew shells were not inventoried as biomass source. Biomass resource at country level has not been retained as a priority, as hydro power potential is very big and still relatively unexploited; and solar and wind would come after, in terms of overall power potential for the country. But this does not exclude any private initiative for power generation. If injected to the grid, the price of energy and the conditions for injection should be negotiated with the national electricity company, which has shown to be a tedious task for some independent producer projects, also because no legal or economic incentives apply to renewables. Thus, the Ministry of Mineral resources and Energy is working on the establishment of a feed-in tariff to clarify the legal setting and encourage small and big renewable energy projects.

There is an official policy on biofuels, enacted in 2009. In 2011, the Inter-ministerial Commission on Biofuels was created (CIB[46]), and a Strategy of Conservation and Sustainable use of Biofuels was announced, having as one of its main objectives to "introduce and spread energy alternatives to wood charcoal". However, since 2014 there does not seem to be any relevant activity from CIB.

More recently, in 2016 the FNDS[47] (National Sustainable Development Fund) has been created, with a stated focus on environment and rural energy. The Fund is hosting a variety of projects, on forest conservation and promotion of rural economies. Apart from that, the Ministry of Environment hosts a large panel of projects supporting creation of local value chains, where cashew by-products (such as shell charcoal) could be eligible[xliv].

On pollution management, Mozambique displays very specific regulation for quality parameters on air and water effluents. It must be highlighted that phenol content in the air is regulated, and classified as a substance leading to strong smells. Indeed, many components in the exhaust composition when burning shells are phenolic components; and these are the cause of the unpleasant smells. There is a law for hazardous waste, with detailed categories, where cashew shells could be classed due to its corrosive nature.

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[45] Interview with Mr Pedro Caixote, technical officer at the Renewable Energy Department in the Ministry of Mines and Energy, interviewed on September 17, 2018.

[46] Comissião Interministerial de Biocombustíveis

[47] Fundo Nacional de Desenvolvimento Sustentável

#### *3.1.4.8 Tanzania*

Regulation in Tanzania is very restrictive: arising from the prohibition of any form of pollution, environmental laws set the need for Water permits for its use. Regarding air pollution, an Emission permit is to be issued if gas emissions exceed the emission limits set in the regulations (see references in Table 20 above). NEMC[48] is the body in charge of Environmental inspection, Compliance monitoring, Environmental planning and Research and Enforcement of sanctions; while as the National Environmental Standards Committee under the Tanzania Bureau of Standards sets the applicable thresholds and pollution limits.

Regarding environmental assessment regulations, in Tanzania all Industries must fill and prepare an Environmental Impact Assessment. Once the Environmental Management Plan is accepted, NEMC would make at least one year' inspections to conduct environmental Monitoring and Audit – for cashew nut processing, the fee for this service is 1,500,000 TZS.

In Tanzania, the electricity market has been recently open to private investment. This means that the legal framework enables private actors to produce and distribute electricity. As part of the strategy to attract foreign investment, the legal frame is very clear, and special provisions to guarantee grid connection and feed-in tariffs are published for renewable energies, depending on the source and the size of the system. For example, for biomass power plants, a 200kW plant would get its energy bought at US$0.179/kWh, while a 1MW power plant would get US$0.147/kWh. Of course, individual agreements with retail clients can be done out of this scheme.

[48] National Environmental Management Council

## 3.2 Stakeholder analysis and the institutional roles and responsibilities

In this section, per country the relevant stakeholders are mentioned, including their role in cashew by-products.

### 3.2.1 Benin

In Benin, in the National Plan[xlv] the place for by-products in cashew processing is very limited. Although the vision is that 50% of the projected RCN quantity (140,000 Mt RCN) is processed in the country, producing an estimated quantity of 100,000 Mt of shells, the issue of by product processing has just a marginal place in that strategic plan. The focus in Benin is on the stability of the RCN supply.

The main institutions in Benin are the CNTC, representing the processors and IFA (Interprofession de la Filière Anacarde), representing all actors in the cashew sector. The CNTC expressed their interest in viable by-product solutions, in term of studies and business cases. Apparently, a strategy on by-products, supported by all processors is not developed.

### 3.2.2 Burkina Faso

In Burkina Faso, the Comité de l'Interprofession (CIAB) created since 2012, has taken the lead in the organization of the sector. It is the umbrella institution of the organisations representing cashew farmers (UNPA[49]), processors (ANTA[50]), and traders (UNCEA[51]). The Committee is aware of the problem of waste, but still faces the stuttering involvement of some of the institutions that should take head-on the issue. Both professional groups (CIAB and ANTA) have, themselves, a limited power of influence and focus their activities in managing relations between producers, processors and traders, especially about the regulation of the price of the nuts. The priority has been on the regulation of the export of RCN, which led to the decision of establishing an export tax in March 2018. In their mission, the CIAB has not yet included the by-products.

Given the weak engagement of the sectorial and official bodies in question, cashew processors themselves have looked for support from other entities such as NGOs or research institutions, to develop solutions adapted to their context[52].

### 3.2.3 Côte d'Ivoire

In Côte d'Ivoire, the Conseil du Coton et de l'Anacarde (CCA), has taken the lead role in the organization of the sector. The GIC-CI (Groupement Industriel de Cajou de la Côte d'Ivoire) is also a representative and influent organization. The priorities are on regulation of export of RCN; stabilization of RCN prices and attracting finance. For the moment there is insufficient stability in supply of by-products to ensure the investments in by-products. From the environmental and energetic point of view, there are no barriers, but the conditions for economic ventures are not in place. There is a vision of processing centers: 4 (Bouaké, Korhogo, Seguéla, Bondoukou) with Odienné as 5th option. These centers must at least process 100.000 Mt RCN each. Then there is enough concentrated by-product for by-product processing at big scale (power generation).

[49] Union Nationale des Producteurs d'Anacarde
[50] Association Nationale de Transformateurs de l'Anacarde
[51] Union Nationale des Commerçants et Exportateurs de l'Anacarde
[52] SNV, RONGEAD, 2iE, Fullwell Mill, Isomet and more

### 3.2.4 Ghana

Ghanaian environmental bodies can assess industrialists on best practices. NCPCG has been created to promote circular economy and energy and resource efficiency in the industrial sector, and has experience in similar cases. Both NCPCG and EPA have qualified staff to assess and accompany the factories into greening their process.

The ACPG (Association of Cashew Processors Ghana) has just been created in 2018. The former CIAG is no longer active. The ~~Board~~ association has set the goal of bringing to life again the Ghanaian cashew processing industry. Their vision is to accomplish three steps of development of the industry, by accompanying and assessing the industrialists to:

1. Open or re-open a number of small-to-medium units (up to 1,500 MT/year capacity) that would be located around one or two poles, forming a primitive cluster; until attaining 50,000 MT RCN processed within 5 years. These units would not necessarily do the whole process but specialize in one of the steps. Unfinished kernels could be sold on export, or to bigger processing centers inside or outside the cluster.
2. The smaller processors would sell their unfinished products to a bigger processor in the cluster.
3. The sector would bring in intermediary companies to recover shell waste. These companies would become also members of ACPG. This third step is considered only at mid or long term.

At the Ministry of Trade and Industry, one office is dedicated to the Cashew desk. According to the representative of the desk[53], new regulations to protect cashew industry are to come before the beginning of the year 2019 season, like an export tax levy on cashew. He expressed the commitment of the Government of Ghana to support the processing industry and encouraged ACPG to express their needs of skills development or support to gather investment. There are also number of programs aimed at creating employment through entrepreneurship, giving advice to SMEs and advocating for a more convenient regulatory framework for the existing SMEs. The BUSAC[54] fund, worked with CIAG (Cashew Industry Association Ghana) on advocacy for a regulation ~~of~~ on the RCN prices; and gave strategic support to cashew farmers and processors. It would be possible for ACPG to benefit from support of BUSAC to overcome one of the identified threats of the sector: regulation, pricing, or even awareness about cashew by-products. Similarly, the Skills Development Fund provides quality-oriented, industry focused training programs and complementary services. Priority is given to enterprises engaged in agro-processing. Applications to benefit from the Fund must be demand driven, i.e. there must be a market demand for a specific skill or feature in a product/service provided. Up to 20% of the funds allowed can be equipment costs. Through the SDF tool, a comprehensive training of the cashew processors could be submitted, aiming at developing the necessary skills to extract CNSL and use the cashew shell cake, or process & marketing of any other product: shells to charcoal, CNSL as fuel, CNSL refining… Provided that processors in Ghana reactivate their activities with the new vision stated by ACPG, they could benefit from this kind of funds.

[53] Mr Kwasi Ofori-Nantwi, interviewed on May 3, 2018

[54] Sponsored by DANIDA, USAID and EU

### 3.2.5 Guinea-Bissau

Ministries contacted were the Ministry of Industry, Energy and Natural Resources (Directorate of Industry and Directorate of Energy); and the Ministry of Environment. The main observation outlined by all of them was the lack of political engagement to promote cashew processing industry. Paradoxically, cashew nuts account for 93% of the country's export incomes. Some actions were undertaken to promote a local industry some years ago, by giving credit facilities to small cashew processors; and at the same time harness the energetic potential of the shells, by installing power generation units running on cashew shells. FUNDEI was a central actor in the formulation and implementation of this project. However, all these efforts could do little to build a sustainable processing chain. Regarding support to processors, focus should have been put on a better control of the finance flows and technical and managerial support to the new entrepreneurs.

Limited knowledge and experience with project development led to mistakes in technology selection, business modelling, plant location, technical support and training of staff, or maintenance needs. As a result, commitment ~~of~~ from the beneficiaries was low and technologies were quickly abandoned.

Still, most public workers interviewed reported ~~a~~ lack of means (financial, material and staff) to fulfill their missions. Without the essential resources, public services are unable to monitor the projects involving them, yet achieving their day-to-day mission.

The World Bank is still active in supporting Guinea-Bissau's private sector and agri-industry, via the PRSPDA project – the same who facilitated the funds for the power production systems in 2013; documents and consultancy works on enhancement of the private cashew processing sector via this project have been found, as old as of 2004. The vision nowadays, according to the Word Bank's officer[55], is to give specific support to existing processors – those running, and others who have ~~are now~~ stopped – to update their equipment, improve managerial skills, and fundraising capacity. A plan to re-launch the CPC (Cashew Processing Center at Sicaju's site) is being developed, together with an assessment of the 14 existing middle-size processing units. However, information about this plan was not given by any of the public institutions mentioned above. Even ANCA-GB[56] only mentioned the Government's intention to launch again a credit line to fund processors for the start of next season.

All the actors refer to exhaust fumes from the chimney as a major environmental issue, probably due to previous experiences (power generation at Safim, and cottage processors using very rustic technology, without a proper conduction of flue gases).

### 3.2.6 Kenya

A specific cashew sector organization does not exist, only that processors can be member of the NutPAK (Nut Processors Association of Kenya). NutPAK is a member organization for all type of nuts, including cashew nuts. NutPAK is a partner of the ACA[57] and seeks to connect the African developments on cashew with the actors on national level. Up till now, NutPAK represents the interests of the sector at the national level. We did not observe an active participation and connection between NutPAK and the individual processors and between processors. Considering the overcapacity of industrial capacity in relation to the RCN production in Kenya, and per consequence the competition on RCN, more collaboration could lead to more effective sourcing. Moreover, from the government perspective, cashew is not perceived as a priority cash crop.

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[55] Mr Mário Alfredo Mendonça, interviewed on August 22, 2018

[56] Agência Nacional de Caju da Guiné-Bissau

[57] Source: http://www.hortinews.co.ke/2016/02/01/kenya-cashew-nut-stakeholders-seek-to-improve-production/

### 3.2.7 Mozambique

Compared to other African countries, Mozambique is a vast country, featuring a diversity of climates and natural resources, thus its industry is diverse. Cashew industry has existed in the country for decades, though it completely disappeared in the 1990s because of a report from the World Bank, where it was argued that Mozambican industry was not competitive and that the country could earn more from selling the raw nuts than in processing[xlvi]. This trend started to switch in the years 2000, just after the creation of the National Cashew Institute (INCAJU) in 1997. In the following years, international organizations with Technoserve leading efforts helped processors restart and pleaded for the country's focus on the processing industry as a source of stable employment and wealth. The Association of Cashew Industrialists AICAJU was created in these times. Although Mozambican processing industry today has attained a remarkable level of processing capacity, and a law was adopted in 2017 aiming to secure RCN supply to the local industry, INCAJU still focuses in supporting cashew production, promoting and regulating RCN exports[xlvii]. INCAJU itself does not give technical support or institutional linkages to promote value addition to by-products. USAID's project MozaCaju dedicated some efforts to by-product development, specifically by facilitating funds for the CNSL extraction plant in Condor Nuts; the rest of the actions are focused on cashew apple.

All in all, attention put on the cashew processing sector is increasing in the recent years, and we can expect an enforcement of the regulations aimed to protect cashew industry[58]. INCAJU is reviewing its own role as a key stakeholder in the cashew sector, and stated that a strategy where by-products are considered would be put in place for the period 2021-2030[59]. From 2018 to 2021, Mozambican institutions will receive support from Nitidae, and specifically INCAJU's strategic management should be reinforced[xlviii].

The legal frame to prevent, monitor and manage pollution is very clear and one of the most advanced. However, when interviewed the competent authority in environment[60], regulations are often not enforced at the cashew factories; one of the reasons given is that the resources of the competent Ministry are very limited to ensure a control or assessment services to processors, on implementation of best practices. Not all the factories have elaborated the – compulsory – environmental assessment report, and even some of them have been fined. There was no awareness on the potential of by-products, or the good practices to avoid air pollution.

There is anyway an unexploited potential of shells in the province of Nampula. AICAJU and some other private promoters do see an opportunity in using the shell for power production purposes; surprisingly, this interest would justify for them the investment in CNSL extraction equipment. AICAJU and a local company, Electrotécnica Lda, have undertaken the first contacts for a discussion on a pilot project for power generation from de-oiled shell, that would be granted by UNIDO; but the lack of some specific technical competences and human resources to develop the idea are delaying this project. The idea is to install a small generation equipment to supply electricity to one of the factories – around 300 kVA.

Also, from the government's side, the project led by Electrotécnica is somewhat known, but for the moment it did not receive any official support.

[58] As stated by Nitidae and Technoserve's officials
[59] Interview with Mr Santos Frijone, INCAJU, September 18, 2018
[60] Interview with Mr Victor Lopes, Direcção Provincial do ambiente, Nampula, on September 14, 2018

### 3.2.8 Tanzania

The story of Tanzanian cashew industry deserves to be displayed in this report, as a vivid example for all the countries. During the 1970s, 11 cashew processing factories with an accumulated capacity of around 100,000 MT were constructed with funds from the World Bank. All factories were state-owned and featured mechanized process with Italian or Japanese technology. These factories are very cost-efficient, if they run at high capacity. About half of them featured CNSL extraction technologies. Raw Cashew nut production at that time was over 145,000 MT/year. However, production declined sharply in the following decade due to several social and economic factors, and a weak organization of the sector. In the nineties, production was again promoted and raised. The factories were partially privatized, but they could still not run at full capacity, and incurred very high fixed costs. Most of them remain idle nowadays, still due to the inability to run at low loads, mixed with the historical difficulties of processors to raise sufficient funds. The example of the Agrofocus (ex-Newala-I) factory, with installed capacity of 10,000 MT, currently closed, is a paradigmatic example. In the meanwhile, several processing units established around Dar es Salaam and in the Mtwara and Tunduru regions, bringing in Indian technology, which runs at lower fixed costs. But the cashew industry not only suffered from an unfortunate choice of technology, also difficulties to engage sufficient staff have been reported. Several diagnostics of the processing sector were developed in 2012 and 2013, drawing the main lines to ensure the sector's sustainability. A better regulation of the sector is one of them[xlix], but observation is made that the industry is highly energy-consuming (heat and power), while cost of energy is high. The exploitation of by-products to improve the profitability and lower production costs was one strong recommendation drew by 3ADI in their report[l], as it was the implementation of methods to reduce water consumption and recycle it. Water is indeed a scarce resource in Tanzania.

Five years after the publication of these reports, no significant changes have been observed in Tanzanian cashew industry. Only some measures facilitating kernel exports have been reported. RCN Production is still growing, but processors still encounter serious problems to secure their RCN stocks. Some units are steadily growing, though it must be recalled that Olam decided to move to Mozambique in 2014. Tanzanian authorities have not yet taken actions in support of the cashew processing units. Mismanagement of public funds is one of the reasons: since 2015, 3 cashew processing factories were announced through the Cashew nut Industry Development Trust fund (CIDTF) – an independent body from the CBT. In fact, this entity was dissolved end 2016 by the Government, after considering that the goals set at its creation in 2010 were not met[li]. CIDTF was receiving the export levy over the RCN sold via the official warehouses system. The Fund committed at its creation in 2010 to assist in inputs sourcing and distribution to farmers, support in training and extension services, supporting small and medium processors, and investment planning amongst others; but CIDTF was only engaged in the first of this list.

The Cashew nut Board of Tanzania (the reference institution in Cashew) is mandated to promote value addition for the country through all the cashew chain, including processing. Unfortunately, and alike other equivalent bodies in other countries, it has historically focused in cashew production and driven on exports results. Although the CBT has existed for a long time, the officers encountered[61] showed little knowledge on the potential of by-products, and sometimes managed outdated information about the processors in the country. Anyhow, it was perceived a big interest in the by-products issue, and the current Director is willing to work on it to help processors thrive[62].

Regarding compliance with environmental regulations, NEMC is in charge and declared being aware of the poor practices regarding waste management – especially shells, which are often burnt in open pits. However, little enforcement of the regulations is done. As NEMC officials pointed, this is a

[61] Interview with two officials at CBT, Sept 11, 2018

[62] N.b. Just a few weeks after handing out the final report, the Tanzanian government undertook a major change in the cashew policy, starting from the pricing of RCN and the role of CBT in the cashew value chain. Thus, Prof Wakuru Magigi was dismissed from the Director General of CBT. Source: thecitizen.co.tz, Oct 26 2018.

matter of ressources. In particular, NEMC offices charged for the biggest cashew breeding and processing area in the country (around Mtwara, Lindi and Ruvuma) find themselves without proper equipment, sufficient staff and specific training to follow-up cashew processing impacts on populations and environment. During the interviews, NEMC embraced the idea of power generation with cashew shells with enthusiasm and showed interest in knowing more about the environmental impact mitigation techniques for the fumes.
Finally, there is an Association of Cashew Processors in Tanzania, though the contact has not been possible to-date.

### 3.2.9 International policies and multi-country stakeholders

#### *3.2.9.1 ComCashew*

ComCashew (initially ACi) is a multi-country project (Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mozambique) that has been supporting the African cashew sector from production to marketing since 2009. The project has a focus on creating linkages to strengthen the actors in the cashew supply chain, and on advocacy to facilitate more appropriate policies for the cashew sector. ComCashew supports producers and processors in the countries of scope, though the training materials developed by the project have benefitted people from more countries than those mentioned above.
Some informative sheets have been developed on by-products, mainly about the cashew apple, and the shell. However, ComCashew admits not having enough information about the potential of by-products[63], so the efforts put in this field have been limited. According to them, there is a need to build knowledge about the reasons to invest in cashew by-products, especially the shell, as it is the biggest pollutant: environmental impact of ~~a~~ lack of processing the shell, related with $CO_2$ reduction and economical quantification of the solutions. ComCashew is willing to promote investments in by-products, and will be sponsoring the development of concrete solutions on by-products at least in the 2019-2020 period, thus contributing to the creation of more knowledge and demonstrating the potential within the sector.

#### *3.2.9.2 Consultative International Cashew Council*

The Consultative International Cashew Council (CICC), recently created by its founding members: Benin, Burkina Faso, Côte d'Ivoire, Ghana, Guinea-Bissau, Guinea Conakry, Mali, Senegal and Togo. There is not yet an agenda available, but taking into account the priorities of the processors from the different countries, it is assumed that the priority will be put on the RCN procurement and market stabilization. Although, this international body can take up the by-product issue, as part of the competitiveness of the African cashew sector.

#### *3.2.9.3 The Sustainable Development Goals of the UN*

The Sustainable Development Goals (SDGs) of the United Nations are adhered globally as a framework for sustainable development with the horizon of 2030. The action of value addition of the cashew by-products relate to and contribute to the realization of the SDGs, particularly to SDG 7, 8, 9, 12, 13 and 17:

| | |
|---|---|
| 7 AFFORDABLE AND CLEAN ENERGY | *Increase substantially the share of renewable energy in the global energy mix through valorisation of cashew by-products* |
| 8 DECENT WORK AND ECONOMIC GROWTH | *Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, which is particularly applicable for the high-value added and labor-intensive cashew sector*<br>*Promote of a development-oriented and supportive policy at regional level* |

[63] Interview with Mrs Mary Adzanyo, May 2018.

| |
|---|
| *Promote inclusive and sustainable industrialization and significantly raise industry's share of employment and gross domestic product, including access to financial services, innovation and R&D combining international and domestic expertise* |
| *Reduce food losses along production and supply chains, including post-harvest losses*<br>*Recycling and reuse of cashew waste and contribute to mitigation actions and integrate sustainability information in reports with KPIs* |
| *Become a carbon compatible cashew value chain*<br>*Integrate climate change measures into cashew-oriented policies, strategies and planning of participating project partners, to prospect models for multiplication and upscaling* |
| *Strengthen resource mobilization of the region to improve domestic capacity for tax and other revenue collection through the increase of the processed cashew exports*<br>*Implement an effective public-private partnership, building on the experience and resourcing strategies of partnerships* |

# 4 Identification and Evaluation of Opportunities and Risks

The opportunities and risks are analyzed on two main dimensions per country:

1. the **comparative analysis** of the unexploited potential on value addition of the cashew shells, based on the model and assumptions of the CashUCalculator. Some assumptions used in the model to quantify estimations of by-products, energy and carbon in the current situation and a potential scenario, with optimization of production of energy and carbon balance :
    a. The current situation is based on the total RCN quantities processed (ref. Table 6). Other parameters used are based on previous mentioned information on by product processing in the cashew sector.
    b. The electricity consumption of the processors the following assumptions are made:
        i. The average electricity consumption per Mt of processing factories is determined on basis of survey data: 125 kWh/Mt RCN.
        ii. According to the level of mechanization, a disaggregation of processing factories into 3 categories is made (1. Manual with 75 kWh/Mt RCN; 2. Semi-industrial with 125 kWh/Mt RCN; 3. Mechanized with 175 kWh/Mt RCN)
        iii. For the current level of mechanization, the average level of most of the processed RCN is identified. For the projected level, the mechanized processing is identified.
    c. In the current situation, 100% of the produced CNSL is for export. For the potential scenario of the CNSL market, the assumption in the projection is based on a 50% share of the local market for CNSL-fuel and 50% for export.
2. The **SWOT analysis**, where the environmental, social and institutional opportunities and risks per country are assessed. An overall synthesis of the technical, environmental, institutional and economic feasibility of cashew by-product development, including recommendations for research, investments and institutional policy development on global level. Based on the SWOT analyses, propositions are concluded: the headlines of local initiatives that should be a model for their neighbors and receive support as such, from ACA and/or other sectorial institutions.

## 4.1 Assessment of the unexploited potential

### 4.1.1 Benin

| Processing parameters | Current | Potential | |
|---|---|---|---|
| Processing capacity (in RCN/yr) | 14,553 | 23,500 | Mt |
| The % of shells from RCN | 70 | 70 | % |
| % of shells for CNSL extraction (mechanical) | 52 | 100 | % |
| % of shells for CNSL extraction (thermal) | - | - | % |
| % of shells for gasification | - | - | % |
| % of shells sold directly | 38 | - | % |
| % of shells for own thermal energy | 0 | - | % |
| Quantity of wood for own thermal energy | - | - | Mt |
| Mechanization level | mechanized | mechanized | |
| Electricity consumption factory | 2,546,775 | 4,112,500 | kWh |

| Output | Current | Potential | |
|---|---|---|---|
| Quantity of shells | 10,187 | 16,450 | Mt |
| Quantity of shells (for mechanical extraction) | 5,250 | 16,450 | Mt |
| Quantity of shells (for thermal extraction) | - | - | Mt |
| Quantity of shells (for gasification) | - | - | Mt |
| Quantity of shells sold directly | 3,877 | - | Mt |
| Quantity of shells for own thermal energy | 9 | - | Mt |
| Quantity of T-CNSL | 1,155 | 3,619 | Mt |
| Quantity of electrical energy produced | - | 9,409,733 | kWh |

| KPIs | Current | Potential | |
|---|---|---|---|
| Total energy balance | 2,495,031 | 32,935,061 | kWh |
| Quantity of carbon credits | -2,068 | 12,243 | tCO2eq |
| Total sales | 268,134,591 | 1,600,807,395 | FCFA |
| Total net profit | 44,121,657 | 370,801,170 | FCFA |
| Carbon emission allowance saving potential | - | 83,359,076 | FCFA |
| Added gross value to RCN | 18,425 | 68,119 | FCFA /Mt RCN |
| Added net value to RCN | 3,032 | 15,779 | FCFA /Mt RCN |

**Observations:**
In Benin, sales of the shells from processors to Fludor started in July 2018. This is considered in the modelling, although the quantities of the current situation are based on RCN quantities processed in 2017. The quantity of shells sold has the potential for value addtion as CNSL and thermal energy, but is not yet the case. A positive energy balance and nearly neutral carbon balance is already reached in the current situation.

### 4.1.2 Burkina Faso

| Processing parameters | Current | Potential | |
|---|---|---|---|
| Processing capacity (in RCN/yr) | 4,874 | 15,500 | Mt |
| The % of shells from RCN | 70 | 70 | % |
| % of shells for CNSL extraction (mechanical) | 36 | 100 | % |
| % of shells for CNSL extraction (thermal) | - | - | % |
| % of shells for gasification | 5 | - | % |
| % of shells sold directly | - | - | % |
| % of shells for own thermal energy | - | - | % |
| Quantity of wood for own thermal energy | - | - | Mt |
| Mechanization level | mechanized | mechanized | |
| Electricity consumption factory | 852,950 | 2,712,500 | kWh |

| Output | Current | Potential | |
|---|---|---|---|
| Quantity of shells | 3,412 | 10,850 | Mt |
| Quantity of shells (for mechanical extraction) | 1,225 | 10,850 | Mt |
| Quantity of shells (for thermal extraction) | - | - | Mt |
| Quantity of shells (for gasification) | 175 | - | Mt |
| Quantity of shells sold directly | - | - | Mt |
| Quantity of shells for own thermal energy | - | - | Mt |
| Quantity of T-CNSL | 270 | 2,387 | Mt |
| Quantity of electrical energy produced | - | 6,206,420 | kWh |

| KPIs | Current | Potential | |
|---|---|---|---|
| Total energy balance | 86,012 | 21,723,125 | kWh |
| Quantity of carbon credits | -953 | 8,296 | tCO2eq |
| Total sales | 53,518,684 | 1,175,277,373 | FCFA |
| Total net profit | 3,058,211 | 275,554,740 | FCFA |
| Carbon emission allowance saving potential | - | 56,484,630 | FCFA |
| Added gross value to RCN | 10,980 | 75,824 | FCFA /Mt RCN |
| Added net value to RCN | 627 | 17,778 | FCFA /Mt RCN |

**Observations:**
In Burkina, there is already a positive energy balance and carbon balance is already reached in the current situation. Burkina Faso has explored developments on CNSL as fuel and the carbonization of shells. This can even yield more value locally.

### 4.1.3 Côte d'Ivoire

| Processing parameters | Current | Potential | |
|---|---|---|---|
| Processing capacity (in RCN/yr) | 52,300 | 159,600 | Mt |
| The % of shells from RCN | 70 | 70 | % |
| % of shells for CNSL extraction (mechanical) | - | 100 | % |
| % of shells for CNSL extraction (thermal) | - | - | % |
| % of shells for gasification | - | - | % |
| % of shells sold directly | 1 | - | % |
| % of shells for own thermal energy | 0 | - | % |
| Quantity of wood for own thermal energy | - | - | Mt |
| Mechanization level | mechanized | mechanized | |
| Electricity consumption factory | 9,152,500 | 27,930,000 | kWh |

| Output | Current | Potential | |
|---|---|---|---|
| Quantity of shells | 36,610 | 111,720 | Mt |
| Quantity of shells (for mechanical extraction) | - | 111,720 | Mt |
| Quantity of shells (for thermal extraction) | - | - | Mt |
| Quantity of shells (for gasification) | - | - | Mt |
| Quantity of shells sold directly | 315 | - | Mt |
| Quantity of shells for own thermal energy | 147 | - | Mt |
| Quantity of T-CNSL | - | 24,578 | Mt |
| Quantity of electrical energy produced | - | 63,906,104 | kWh |

| KPIs | Current | Potential | |
|---|---|---|---|
| Total energy balance | -9,069,813 | 223,678,118 | kWh |
| Quantity of carbon credits | -7,328 | 45,331 | tCO2eq |
| Total sales | 3,150,000 | 10,039,220,098 | FCFA |
| Total net profit | 2,520,000 | 2,117,014,301 | FCFA |
| Carbon emission allowance saving potential | - | 308,643,838 | FCFA |
| Added gross value to RCN | 60 | 62,902 | FCFA /Mt RCN |
| Added net value to RCN | 48 | 13,265 | FCFA /Mt RCN |

**Observations:**
In Côte d'Ivoire there is a real unexploited potential on income, energy and carbon offset. Currently, there is a negative energy balance and carbon balance in the current situation.

### 4.1.4 Ghana

| Processing parameters | Current | Potential | |
|---|---|---|---|
| Processing capacity (in RCN/yr) | 536 | 23,000 | Mt |
| The % of shells from RCN | 70 | 70 | % |
| % of shells for CNSL extraction (mechanical) | 100 | 100 | % |
| % of shells for CNSL extraction (thermal) | - | - | % |
| % of shells for gasification | - | - | % |
| % of shells sold directly | - | - | % |
| % of shells for own thermal energy | - | - | % |
| Quantity of wood for own thermal energy | - | - | Mt |
| Mechanization level | mechanized | mechanized | |
| Electricity consumption factory | 93,800 | 4,025,000 | kWh |

| Output | Current | Potential | |
|---|---|---|---|
| Quantity of shells | 375 | 16,100 | Mt |
| Quantity of shells (for mechanical extraction) | 375 | 16,100 | Mt |
| Quantity of shells (for thermal extraction) | - | - | Mt |
| Quantity of shells (for gasification) | - | - | Mt |
| Quantity of shells sold directly | - | - | Mt |
| Quantity of shells for own thermal energy | - | - | Mt |
| Quantity of T-CNSL | 83 | 3,542 | Mt |
| Quantity of electrical energy produced | - | 9,209,526 | kWh |

| KPIs | Current | Potential | |
|---|---|---|---|
| Total energy balance | 193,791 | 32,234,315 | kWh |
| Quantity of carbon credits | -71 | 1,387 | tCO2eq |
| Total sales | 141,742 | 16,876,331 | GHS |
| Total net profit | 8,100 | 3,502,397 | GHS |
| Carbon emission allowance saving potential | - | 81,649 | GHS |
| Added gross value to RCN | 264 | 734 | GHS /Mt RCN |
| Added net value to RCN | 15 | 152 | GHS /Mt RCN |

**Observations:**
In Ghana, there is already a positive energy balance and carbon balance is already reached in the current situation. Ghana faces an enormous problem on RCN supply, which needs to be addressed first.

### 4.1.5 Guinea-Bissau

| Processing parameters | Current | Potential | |
|---|---|---|---|
| Processing capacity (in RCN/yr) | 5,950 | 12,950 | Mt |
| The % of shells from RCN | 70 | 70 | % |
| % of shells for CNSL extraction (mechanical) | - | 100 | % |
| % of shells for CNSL extraction (thermal) | 50 | - | % |
| % of shells for gasification | - | - | % |
| % of shells sold directly | - | - | % |
| % of shells for own thermal energy | 6 | - | % |
| Quantity of wood for own thermal energy | - | - | Mt |
| Mechanization level | mechanized | mechanized | |
| Electricity consumption factory | 1,041,250 | 2,266,250 | kWh |

| Output | Current | Potential | |
|---|---|---|---|
| Quantity of shells | 4,165 | 9,065 | Mt |
| Quantity of shells (for mechanical extraction) | - | 9,065 | Mt |
| Quantity of shells (for thermal extraction) | 2,100 | - | Mt |
| Quantity of shells (for gasification) | - | - | Mt |
| Quantity of shells sold directly | - | - | Mt |
| Quantity of shells for own thermal energy | 231 | - | Mt |
| Quantity of T-CNSL | - | 1,994 | Mt |
| Quantity of electrical energy produced | - | 5,185,364 | kWh |

| KPIs | Current | Potential | |
|---|---|---|---|
| Total energy balance | -1,041,250 | 18,149,321 | kWh |
| Quantity of carbon credits | -969 | 4,887 | tCO2eq |
| Total sales | - | 480,583,289 | FCFA |
| Total net profit | - | 94,449,535 | FCFA |
| Carbon emission allowance saving potential | - | 33,276,656 | FCFA |
| Added gross value to RCN | - | 37,111 | FCFA /Mt RCN |
| Added net value to RCN | - | 7,293 | FCFA /Mt RCN |

**Observations:**
In Guinea-Bissau, figures show a negative energy balance and carbon balance for the current situation. The existing co-generation is not included in the model, as the running parameters of the co-generation are to be assessed first.

### 4.1.6 Kenya

| Processing parameters | Current | Potential | |
|---|---|---|---|
| Processing capacity (in RCN/yr) | 3,440 | 30,000 | Mt |
| The % of shells from RCN | 70 | 70 | % |
| % of shells for CNSL extraction (mechanical) | - | 100 | % |
| % of shells for CNSL extraction (thermal) | - | - | % |
| % of shells for gasification | - | - | % |
| % of shells sold directly | - | - | % |
| % of shells for own thermal energy | 19 | - | % |
| Quantity of wood for own thermal energy | - | - | Mt |
| Mechanization level | mechanized | mechanized | |
| Electricity consumption factory | 602,000 | 5,250,000 | kWh |

| Output | Current | Potential | |
|---|---|---|---|
| Quantity of shells | 2,408 | 21,000 | Mt |
| Quantity of shells (for mechanical extraction) | - | 21,000 | Mt |
| Quantity of shells (for thermal extraction) | - | - | Mt |
| Quantity of shells (for gasification) | - | - | Mt |
| Quantity of shells sold directly | - | - | Mt |
| Quantity of shells for own thermal energy | 458 | - | Mt |
| Quantity of T-CNSL | - | 4,620 | Mt |
| Quantity of electrical energy produced | - | 12,012,426 | kWh |

| KPIs | Current | Potential | |
|---|---|---|---|
| Total energy balance | -602,000 | 42,044,759 | kWh |
| Quantity of carbon credits | -494 | 8,112 | tCO2eq |
| Total sales | - | 373,809,312 | KES |
| Total net profit | - | 80,039,186 | KES |
| Carbon emission allowance saving potential | - | 9,758,048 | KES |
| Added gross value to RCN | - | 12,460 | KES /Mt RCN |
| Added net value to RCN | - | 2,668 | KES /Mt RCN |

**Observations:**
In Kenya, figures show a negative energy balance and carbon balance for the current situation. For the potential situation, the processing capacity is taken, but RCN supply quantities are currently insufficient.

### 4.1.7 Mozambique

| Processing parameters | Current | Potential | |
|---|---|---|---|
| Processing capacity (in RCN/yr) | 56,100 | 76,100 | Mt |
| The % of shells from RCN | 70 | 70 | % |
| % of shells for CNSL extraction (mechanical) | 12 | 100 | % |
| % of shells for CNSL extraction (thermal) | - | - | % |
| % of shells for gasification | - | - | % |
| % of shells sold directly | - | - | % |
| % of shells for own thermal energy | 10 | - | % |
| Quantity of wood for own thermal energy | - | - | Mt |
| Mechanization level | mechanized | mechanized | |
| Electricity consumption factory | 9,817,500 | 13,317,500 | kWh |

| Output | Current | Potential | |
|---|---|---|---|
| Quantity of shells | 39,270 | 53,270 | Mt |
| Quantity of shells (for mechanical extraction) | 4,900 | 53,270 | Mt |
| Quantity of shells (for thermal extraction) | - | - | Mt |
| Quantity of shells (for gasification) | - | - | Mt |
| Quantity of shells sold directly | - | - | Mt |
| Quantity of shells for own thermal energy | 3,787 | - | Mt |
| Quantity of T-CNSL | 1,078 | 11,719 | Mt |
| Quantity of electrical energy produced | - | 30,471,520 | kWh |

| KPIs | Current | Potential | |
|---|---|---|---|
| Total energy balance | -6,061,650 | 106,653,539 | kWh |
| Quantity of carbon credits | -10,593 | 39,692 | tCO2eq |
| Total sales | 22,683,993 | 413,067,546 | MZN |
| Total net profit | 1,296,228 | 93,202,572 | MZN |
| Carbon emission allowance saving potential | - | 28,636,099 | MZN |
| Added gross value to RCN | 404 | 5,428 | MZN /Mt RCN |
| Added net value to RCN | 23 | 1,225 | MZN /Mt RCN |

**Observations:**
In Mozambique, figures show a negative energy balance and carbon balance for the current situation. As processing quantities are already considerable, investments in further by-product processing seems to be really an opportunity.

### 4.1.8 Tanzania

| Processing parameters | Current | Potential | |
|---|---|---|---|
| Processing capacity (in RCN/yr) | 10,900 | 13,500 | Mt |
| The % of shells from RCN | 70 | 70 | % |
| % of shells for CNSL extraction (mechanical) | - | 100 | % |
| % of shells for CNSL extraction (thermal) | - | - | % |
| % of shells for gasification | - | - | % |
| % of shells sold directly | - | - | % |
| % of shells for own thermal energy | 8 | - | % |
| Quantity of wood for own thermal energy | - | - | Mt |
| Mechanization level | mechanized | mechanized | |
| Electricity consumption factory | 1,907,500 | 2,362,500 | kWh |

| Output | Current | Potential | |
|---|---|---|---|
| Quantity of shells | 7,630 | 9,450 | Mt |
| Quantity of shells (for mechanical extraction) | - | 9,450 | Mt |
| Quantity of shells (for thermal extraction) | - | - | Mt |
| Quantity of shells (for gasification) | - | - | Mt |
| Quantity of shells sold directly | - | - | Mt |
| Quantity of shells for own thermal energy | 620 | - | Mt |
| Quantity of T-CNSL | - | 2,079 | Mt |
| Quantity of electrical energy produced | - | 5,405,592 | kWh |

| KPIs | Current | Potential | |
|---|---|---|---|
| Total energy balance | -1,907,500 | 18,920,142 | kWh |
| Quantity of carbon credits | -1,929 | 6,137 | tCO2eq |
| Total sales | - | 3,398,881,506 | TZS |
| Total net profit | - | 763,369,700 | TZS |
| Carbon emission allowance saving potential | - | 168,084,528 | TZS |
| Added gross value to RCN | - | 251,769 | TZS /Mt RCN |
| Added net value to RCN | - | 56,546 | TZS /Mt RCN |

**Observations:**
In Tanzania, figures show a negative energy balance and carbon balance for the current situation. As RCN quantities are already considerable, investments in kernel processing and by-product processing seems to be an opportunity.

## 4.2 SWOT Analyses

### 4.2.1 Benin

**SWOT PROCESSING UNITS**

| Strengths | Weaknesses |
|---|---|
| - CNSL processing at FLUDOR, which is a first good step in by-product processing<br>- Willingness and individual experiences at the level of individual processors to resolve the by-product issue | - No common strategy developed among processors on by-products<br>- The processing units are geographically scattered, so that concentrated by-product development has high logistical costs<br>- Lack of exchange between factories on practices of by-product processing (each processor is finding out its way and even technology) |
| **Opportunities** | **Threats** |
| - High electricity costs and deficit in energy supply, constituting an opportunity for electricity production<br>- Co-generation on base of the press cake, produced via CNSL processing | - The lack of net metering policy, which complicates co-generation profitability |

**SWOT INSTITUTIONS**

| Strengths | Weaknesses |
|---|---|
| - Existence of the CNTC and IFA<br>- By-products development makes part of the National plan, despite its marginal place | - Institutions representing the sector give a low priority to the issue of waste and lacking an overall vision and strategy on by-products<br>- Low capacity for dialogue between institutions |
| **Opportunities** | **Threats** |
| - Existence of ARE, the regulatory body for energy production and supply to the grid | - The lack of net metering policy, which complicates co-generation profitability |

**Proposition:**
The comprehensive support – in the form of technical, legal and fundraising advice- given by the MCC initiative to the development of a business model and feasibility studies for a co-generation project based in cashew shell cake, is probably a good example to replicate in the other countries, where the potential for power generation from shell waste has been evoked.

### 4.2.2 Burkina Faso

**SWOT PROCESSING UNITS**

| **Strengths** | **Weaknesses** |
|---|---|
| - The main processing units in Burkina active in finding solutions to reach the "zero waste"<br>- Existing relations with research institutions and partners for by product development | - Low capacity of own funding<br>- limited technical knowledge<br>- Distrust of “valorisation technologies" that have not been developed internally<br>- High logistical costs |
| **Opportunities** | **Threats** |
| - The technologies do exist already, elsewhere (India and Brazil)<br>- Burkina is a pioneer in West Africa in developing innovative solutions<br>- High electricity costs and deficit in energy supply, constituting an opportunity for electricity production<br>- Extraction units of CNSL could settle outside of the nut processing units, becoming takers of the shells. The two recommended places are the cities of Bobo-Dioulasso (cumulative capacity of 8000 MT RCN, and have expansion plans) and Banfora - 5000 MT RCN. | - The inability to manage waste (due to economic reasons) gives a bad image of the industry at the vicinity of the factories and, ultimately, at administration level and even among the staff of the factory |

**SWOT INSTITUTIONS**

| **Strengths** | **Weaknesses** |
|---|---|
| - Experience in training technical partnerships with actors of cooperation / development experts<br>- Increased reputation of the CIAB<br>- Burkina's political participation, to adopt common environmental policies in the ECOWAS | - Institutions representing the sector give a low priority to the issue of waste<br>- Low capacity for dialogue between institutions (industry-sector and state sector) |
| **Opportunities** | **Threats** |
| - Most of the waste recovery and treatment solutions have already been tried in at least one of the plants | - Inactivity institutions in terms of regulation and support, can contribute to the degradation of the result of the factories, and ultimately to closure<br>- Environmental policy is not clear |

**Proposition:**

Outstanding examples of what can be done with 100% made local technology can be found on the CHP pyrolizers in Burkina. As it was presented at CIESA, Emissions avoided have been calculated at 2,975 MtCO2eq within the five years that Gebana Afrique has been running its pyrolizer – and increasing the capacity of the factory, while reducing the nuisance to the neighborhood. Many other success stories exist around the use of H2CP. However, many actors in West Africa still think that H2CP is still in the prototype phase. It would be important to spread accurate information about H2CP from a sectorial institution.

Also, the charcoal making technology has been developed in Burkina but in the practice, it does not receive support or the necessary coverage from public institutions. This, linked to the lack of previous experience discourages most entrepreneurs to adopt this technology. Support on development and demonstrations would be welcome.

### 4.2.3 Côte d'Ivoire

**SWOT PROCESSING UNITS**

| **Strengths** | **Weaknesses** |
|---|---|
| – The vision is to concentrate processing in hubs so that supply for processing of byproducts becomes logically viable and there is continuous supply | - Few experiences / initiatives on by-product development |
| **Opportunities**<br>– If processing is concentrated in hubs of 100.000 Mt/yr RCN, there is sustainable supply and cost efficiency in transaction costs; and cardanol processing becomes an option | **Threats**<br>– If the cashew sector delays on stabilizing the RCN market and prices and mobilizing finance, the priorities will not be given to the by product development, but on the RCN sourcing. |

**SWOT INSTITUTIONS**

| **Strengths** | **Weaknesses** |
|---|---|
| - Strong reputation and influence of the CCA and the GIC-CI | - Weak implication of research on cashew by-products |
| **Opportunities**<br>- Inducing environment for cashew processing and the vision to create processing hubs<br>- Technical expertise on industrial level | **Threats**<br>- The price and finance issues for RCN procurement for the processing factories are still the main issue that needs to be addressed; if that is not stabilized, there will not be enough priority for the by-products |

**Proposition:**

Considering the highest RCN production and the number of processors and the processing capacity of all the 8 countries, cashew by-products developing actions should be more developed. In that perspective it the current value addition of the by-products is remarkably low. However, Côte d'Ivoire has the highest potential in terms of value addition of by-products. Moreover, Côte d'Ivoire is already active in the implementation of project that reduce carbon emissions.

Especially the vision of the processing hub development will have a competitive proposition and sustainable supply, that is promising. R&D programs and exposure and exchange (also with the other countries should get a priority.

### 4.2.4 Ghana

**SWOT PROCESSING UNITS**

| **Strengths** | **Weaknesses** |
| --- | --- |
| – The two running units are extracting CNSL | - Little experience sharing amongst processors<br>– Active processors are in a very small number, and depend on urgent sector regulation to survive |
| **Opportunities** | **Threats** |
| – Local market for CNSL: fuel in burners, raw material for paints/resins<br>– Ghanaian industry could absorb all the volume of by-products (cake & CNSL) | - Lack of favorable regulation for the cashew processing sector |

**SWOT INSTITUTIONS**

| **Strengths** | **Weaknesses** |
| --- | --- |
| - Institutions are strong and receptive overall<br>- Entrepreneurship and competitiveness are encouraged by several programs<br>- The legal frame for an eventual Independent Power Producer from cashew shell waste is developed. | - Cashew processing is not a priority for Government<br>- In ACPG's strategy, by products are considered as a late stage of implementation, and not a mainstream issue that should be considered at all stages. |
| **Opportunities** | **Threats** |
| - New management of ACPG<br>- EPA and NCPCG or even AGI[64] are well positioned to work with SMEs and bigger processors on the by-products issue.<br>- Funds are available to close the gap of lack of specific competencies on by-product development and processing. | - Regulations are being adopted very slowly, which has an impact on the real profitability of cashew industry<br>- No specific attention |

**Proposition:**
Linkages with Ghanaian cashew processors and other productive sectors, such as nearby industries but also small entrepreneurs in biofuels, or animal feed, could be sought. Cleaner Production Center Ghana is doing an excellent work on this.
Support to the recently created Association of Cashew Processors in the acquisition of knowledge about by-products.

[64] Association of Ghana Industries

### 4.2.5 Guinea-Bissau

**SWOT PROCESSING UNITS**

| **Strengths** | **Weaknesses** |
|---|---|
| – The biggest processors are in easily accessible locations<br>– A market for cashew shells exists<br>– Power generation from cashew shell is currently happening<br>– CPC/Sicaju facilities are in a good state and still give services to some small processors | - There is not a clear policy on cashew processing, thus, supportive institutions lack of resources<br>- Cottage processors need financial support for procurement and running the sites. By-products are not in their agenda so far. |
| **Opportunities** | **Threats** |
| - Local market for CNSL: fuel in burners or generators<br>- Processors looking to value addition of shells and by-products<br>- Increasing cashew processing capacity | - Cashew processing, and industry in general is not a priority for government<br>- Despite the equipment received in 2013, processors lack of technical knowledge to service the power units for themselves, so they are unable to run the existing facilities. |

**SWOT INSTITUTIONS**

| **Strengths** | **Weaknesses** |
|---|---|
| - Experience with biomass power generation<br>- In a context of a decentralized power generation system, national energy policy is to encourage micro-grids; and biomass is considered as an important renewable resource. | - There is not a clear policy on cashew processing, thus, supportive institutions lack of resources<br>- The satellite-processing model is appropriate to empower small industrialists, but there is no support on by-products<br>- The industry remains opaque – there are not official figures about active processors and capacities |
| **Opportunities** | **Threats** |
| - Other biomass sources such as sugarcane bagasse and rice husk are available near to the shell sources.<br>- Small processors could be interested in cashew shell charcoal | - Implementation of Renewable energy projects rely on the dynamism of a few individuals on the public side; out of cooperation programs, there is a lack of official support<br>- Specific regulations on Renewable energy and Pollution control are not yet developed<br>- Lack of proper project planning & monitoring has led to bad experiences, and investments being abandoned very quickly; if the project strategies do not change, the same errors could be repeated. |

**Proposition:**

There is a working example of power production from cashew shell in Guinea-Bissau; moreover, it is a small capacity system (130kWe). The technology is also rather unique (steam machine) and several maintenance difficulties have been reported. This is linked to the lack of technical support & spare parts, but also must do with the capacities of operators and managers. A closer view to the system would help determining the applicability of this kind of systems in the African context, and eventually an implementation plan.

### 4.2.6 Kenya

**SWOT PROCESSING UNITS**

| **Strengths** | **Weaknesses** |
|---|---|
| - Reduced air pollution, because of the mixture with another biomass<br>- Willingness and individual experiences at the level of individual processors to resolve the by-product issue | - No common strategy developed among processors on by-products<br>- Lack of exchange between factories on practices of by-product processing (each processor is finding out its way and even technology) |
| **Opportunities** | **Threats** |
| - Well-developed available biomass technologies in the country (e.g. co-generation)<br>- Co-generation on base of the press cake, produced via CNSL processing<br>- A leather processor in Kilifi, procuring cashew testa form processors | - Big concern about RCN supply, the priority on the agenda |

**SWOT INSTITUTIONS**

| **Strengths** | **Weaknesses** |
|---|---|
| - Documentation and expertise of NEMA is of high quality<br>- By-products development makes part of the National plan, despite its marginal place | - No specific cashew sector organization and lack an institutional specific platform for cashew<br>- Low capacity for dialogue between institutions |
| **Opportunities** | **Threats** |
| - Experiences with the CDM (40 projects approved); cashew by-products can be formulated and submitted | - Relatively low priority from the governmental side on cashew; if the investments in the cashew sector remains limited, RCN supply and hence the by-products will be difficult to develop |

**Proposition:**

The development of the environmental standards and the institutional incorporation (including the online availability) is an example for other countries.

The hosting of the Climate Change Act and experience with the development of CDM projects is another experience that can benefit other countries.

Coverage on the use of testa as tanning agent; which can be extended to many other countries, and displace chemical tanning.

Creation of a cashew nut representative body – or promotion of linkages/experience sharing amongst cashew processors.

### 4.2.7 Mozambique

**SWOT PROCESSING UNITS**

| **Strengths** | **Weaknesses** |
|---|---|
| – Processors are concentrated around one main axis, featuring a main road, electrical grid and railway<br>– Experience in CNSL extraction<br>– Willingness for power generation projects | - Appropriate cookstoves for cashew shell and cake exist, but have not been disseminated yet<br>- Little support from institutions to enhance profitability of processors, which remains their main issue |
| **Opportunities**<br>– Local market for CNSL: fuel in burners or generators. There is energy and fuel consuming industry near some cashew factories.<br>– Local market for CNSL as protective wood coating<br>– Local market for shells and de-oiled cake, as household fuel<br>– Charcoal from cashew shell would find a market near Maputo, where some units are located | **Threats**<br>- The engagement of INCAJU in the by-products field seems essential to mainstream efforts and promote conducive policies at national level |

**SWOT INSTITUTIONS**

| **Strengths** | **Weaknesses** |
|---|---|
| - AICAJU is active in representing the processing sector's interests, and shows interest in by-products<br>- Institutions are open to share information and collaborate | - Institutions lack of resources and knowledge to enforce regulations<br>- The potential contribution of cashew shell and CNSL to the energetic panorama has not been considered yet, at institutional level<br>- INCAJU is not promoting technologies to reduce environmental impact of cashew waste |
| **Opportunities**<br>- Strong commitment to promote electrification<br>- INCAJU and related bodies is receiving assessment to redefine its role in the coming years (MozaCaju, ConnectCaju, ACAMOZ) | **Threats**<br>- The regulatory environment is not enforced in many cases<br>- Biomass and biofuels do not receive a serious official engagement<br>- RCN production and export regulation remains the government's priority, for cashew sector<br>- Lack of proper project planning & monitoring has led to bad experiences, and investments being abandoned very quickly; if the project strategies do not change, the same errors could be repeated. |

**Proposition:**

Work with INCAJU to support in the redefinition of its roles; INCAJU can be a key stakeholder in the development and promotion of cashew by-products. AICAJU should also receive backing from INCAJU or other institutions, to help build their projects related with by-products.

### 4.2.8 Tanzania

**SWOT PROCESSING UNITS**

| **Strengths** | **Weaknesses** |
|---|---|
| – Some clusters being formed: in Mtwara and Masasi<br>– Experience in CNSL extraction and use as a fuel | - Little co-operation and share of information amongst processors, and to the public |
| **Opportunities**<br>– Mtwara may soon host a CNSL extraction and power generation unit, with waste from several factories<br>– Some old, idle CNSL extraction equipment may be available for adoption by a new entrepreneur<br>– Local market for CNSL as protective wood coating<br>– Local market for de-oiled cake, as household fuel | **Threats**<br>- Little support from institutions<br>- When dealing with administration, procedures are reported to be tedious |

**SWOT INSTITUTIONS**

| **Strengths** | **Weaknesses** |
|---|---|
| - Actively searching investment and eager to create a regulatory frame to attract investors | - Institutional response is slow<br>- CBT is not focused on cashew processing<br>- Industry in general is not a priority |
| **Opportunities**<br>- Promotion of by-products and of good environmental practices can give a new and positive image of the cashew industry | **Threats**<br>- The regulatory environment is not enforced in many cases<br>- RCN production and export regulation remains the government's priority, for cashew sector<br>- Lack of proper project planning & monitoring has led to bad experiences |

**Proposition:**

The Cashewnut Board needs to be renovated, just like its homologue in Mozambique. Given the big average size of the processing units, the key in Tanzania would be to attract investment to implement big-scale solutions; and help the smaller ones to join efforts so that they can give value to their waste as well.

# 5 Main conclusions and recommendations

Proposes a set of actionable recommendations by which these issues can be addressed at both a policy and project level to enhance environmental sustainability and social equity of the cashew sector development.

## 5.1 Global analysis

### 5.1.1 Key findings

Some **key findings** on the global level of the cashew sector and its by-products:

- In all African countries, the cashew processing still faces the issue of **weak competitiveness** of cashew processing. The main concerns of processors are focused on the RCN supply: price stability, export bans and regulations, quality and finance. This unreliable supply has contributed to the inability of factories to produce at full capacity. In 2017 in West African countries, processors processed about 30% of their potential capacity. Sector associations and sector dialogue is concentrated on this issue. The same trend is observed in East Africa, but with less intensity from government's perspectives.
- Nearly all factories use the shells **for thermal energy**, mostly as fuel for the boiler. The consumption of shells for thermal energy varies from 5-25% of the shells produced. In some factories the H2CP installation, where it is suitable with the boiler ("vertical boilers"), is applied, where shells are pyrolyzed and around 10% charcoal is recovered. The case where de-oiled shells are used as combustible for thermal energy seems to be feasible, but rarely found at processors.
- Globally, over the 8 countries visited, the priority given to the value addition of the by-products is not high. Although, the shells accounting for 70% of the RCN biomass, this waste is deposited or removed, but **value addition is hardly practiced**. A few processors (7 of the 66) have invested in CNSL processing, but the plants are running off and on, due to the low T-CNSL sales prices on the international market. Next, ~~a~~ few initiatives on co-generation were identified (1 in Benin, 1 in Côte d'Ivoire, 3 in Guinea-Bissau, 1 in Tanzania and 1 in Mozambique), but the main constraints are (i) lack of the feed-in tariff for electricity supply to the grid and (ii) the lack of constant and reliable high quantity of shells.
- Nevertheless, the overall **most-efficient strategy** for value addition of by-products is the processing of CNSL and co-generation of the de-oiled cake. The condition is a secured supply of minimum 15,000-20,000 Mt shells per year, allowing co-generation capacity of 1.5 MWe. At the current stage of development, some processing hubs have reached that volume – they have been highlighted in the report. In countries where processing has reached a certain level and even geographically concentrated, individual processors have done feasibility studies (Benin, Côte d'Ivoire), but there is not yet an installation realized. A big hurdle for the co-generation is the lack of policy on the feed-in tariff. Liberalization and privatization of electrical energy production and supply is of recent date and there are few experiences in other sectors, although successful examples can be found in every country.
- There is an unexploited **potential** of cashew by-products. With the total RCN production of nearly 1.4 million Mt and given the average of 10% processed RCN in the countries: out of a total potential quantity of nearly 1 million Mt of shells/yr, currently a quantity of about 100,000 Mt is of shells is produced in the study countries: about 25% is processed (50% of CNSL production and the rest for thermal energy purposes). The main potential (±80%) is in the value addition of the shells and less in the kernel and testa value addition. Therefore, the focus in the comparative analysis is on the value addition of shells. Conclusions and observations on the comparative analysis of the scenarios:
    - Comparing the first two scenarios, there is an unexploited potential of US$16m, or US$110/Mt RCN of turnover that is not exploited in the current situation. For the factories it is a missed potential of US$25/Mt RCN. Scenario 3 and 4 are based on the same technological assumption, that the added value per Mt RCN remains the same.

There is a potentially a value addition of US$170m with a rough estimated net profit for the businesses of US$39m
    - The value addition of the cashew shells can contribute to a positive energy balance that varies from 211,081 MWh to 1,975 GWh
    - The value addition of the cashew shells can contribute to a positive carbon balance that varies from 58,560 to 548,135 tCO2eq.
- A **combination** of the two technologies (CNSL extraction and co-generation from shell cake) is to be perceived as the best way of value addition of the cashew by-products, as any experience to burn the shell with the oil would create problems in the equipment – and burning CNSL with a solid fuel is a loss of value.
- Further **derivatives of CNSL** like cardanol processing are is not yet a viable options for African cashew processing industry due to scale of operations. Cardanol processing needs a good scale ~10-12K Mt of CNSL to make it lucrative enough to get investments.
- Moreover, **small scale initiatives** and solutions (production of charcoal through carbonization of shells, power generation with steam machines) are found at several processors in the 8 countries assessed here and there, but the viability and sustainability is not really confirmed, as most of these initiatives are in the R&D phase and depend on subsidies. More experience on testing and scaling up this equipment would be required to confirm the business case.

Some **key findings** on the global level on policies and institutional level:
- We observe a potential leading role in promotion of by-products through these institutional sector organizations:
    - IFA in Benin
    - CIA in Burkina Faso
    - FIRCA and CCA in Côte d'Ivoire
    - EPA and National Green Production Center in Ghana
    - FUNDEI in Guinea-Bissau
    - NutPAK in Kenya
    - AICAJU & INCAJU in Mozambique
    - NEMC in Tanzania
- Considering the recent date of creation, their reputation has increased among the industries and towards the governmental bodies. They have proven to work inter-ministerial, which is necessary. Although, we have not found on the level of the sector organization a sound vision and strategy on by-products. This is related to the priorities on RCN supply and market. Moreover, the by-products have an institutional complexity: the cashew by-product policy has different dimensions and implications for different ministries:
    - Environmental (adverse and beneficial) effects, by waste streams and renewable energy for the Ministry of Environment
    - Value addition and trade, by specific (energy products) for the Ministry of Energy and Ministry in charge of Industry
    - Energy issues, often hosted at a separate Ministry of Energy
    - Finance, by tax regulations, for the Ministry of Finance
- **Environmental legislation frameworks** are well established and institutionally embedded. Some countries are more advanced. Work can be done on standardization and professionalization of the environmental standards procedures and control measures.
- Policy **regulations on electricity production** and supply in all countries are not well established. Particularly in West African countries, this vacuum constitutes a risk for the business case on co-generation.

### 5.1.2 Underlying causes

The underlying main ***causes*** for the low priority for by-products are linked to:

- the **weak application** of technology to the cashew by-products. Biomass energy technologies are worldwide developed and supplied, but the CNSL component in the shells complicates the processing of shells. Application of cashew shells for the existing biomass energy technologies needs R&D for adaptation of technologies.
- the **unreliable suppl**y of cashew shells, that is directly related to the instability of ~~the~~ processing in the countries. We observed an underutilization of the processing facilities due to unreliable supply of RCN.
- **lack of awareness on policy level** on the unexploited potential of the cashew sector, including the cashew by-products; the cashew policy agenda is dominated by securing the RCN supply for processors
- the fact that **by-products are not a priority investment for cashew processors**, just because it is not their core business; most of them would rather sell their waste to third parties, who would process them to make valuable products.
- Another negative factor for by-product development is the low CNSL export price. Considering logistical and processing costs, it makes CNSL processing for export hardly viable (±0-5%). However, low prices may just be due to the unknown potential of African CNSL by buyers.. **Marketing** and communication efforts would attract the attention of both buyers and investors.
- relatively **low return on investment of some solutions**, which makes it unattractive venture case for investors
- to the fact that many factories face a **difficult financial situations,** processors often find the cashew RCN and kernel market very fluctuating, and national laws have barely protected them from these risks. This situation does not help them to consider investments for environmental impact mitigation or by-products processing.
- In most cases, **environmental authorities do not effectively enforce laws on waste management and emissions**, so the cashew factories do not perceive urgency for finding a sustainable solution to their waste.
- **lack of a coherent vision** and strategy at national level on the cashew by-products potentials and constraints. The cashew agencies at national level are focused on RCN supply, pricing and marketing of kernels, while the by-product issue has a low priority. Another fact is that the the by-product issue lacks an integrated approach. The public bodies consider the by-product issue from its own responsibility (the Ministry of Environment on compliance with environmental standards, the Ministry of Energy on the potential of energy from by-products and Ministry of Commerce on the industrialization and trade). An institutional platform that synthetizes the issue and contributes to coherent policy development is absent or very weak (e.g. the representative agencies of cashew sector at national levels). Although, we observed a keen interest of stakeholders to take up the issue, also from the governmental side. Countries having a Clean Development Center (Ghana, Kenya) demonstrate giving public support to the waste-to-resource developments and have an experience industrial symbiosis.

The last couple of findings of the lack of a coherent vision on the by-product issue and the different (lack of) interests of the stakeholders are interlinked. ~~During~~ The study found ~~the~~ awareness on ~~of~~ the importance to consider the by-products from an **integrated (economic, energetic and environmental) perspective**. This joint vision should be strategized on sector level and lead to multi-stakeholder investments (e.g. Public-Private-Partnerships) was investments in by-product will impact public and private benefits. Investments in by-product processing capacity, contributing to the economic, energetic and ecological KPIs justify public and private investments. This should be the starting point for the viability and sustainability of the business cases.

### 5.1.3 The current effects

The ***current effects*** in terms of analyzed consequences of the low attention to by-products are multiple:

- Despite the low attention to the value addition of cashew by-products, there is an economic potential value of US$125/Mt RCN from by-product processing, by applying an optimized combination of technologies, where the entire shell by-products end up into energy (and if international CNSL prices allow, they end up into CNSL derivates). This potential value constitutes up to ± 20% of the RCN procurement price. The CNSL is economically the most important part of the by-products, but (if exported) at the same time also the most vulnerable to world market prices. Hence, this could contribute significantly to the competitiveness of the cashew sector in the African countries. This **potential is unexploited** and has an adverse effect on the competitiveness of the cashew processes on global level.
- Processors struggle with the **non-conformity** towards the environmental standards. Practices as heaps of cashew shells near the factories, air pollution are regularly observed. Removal of the shells to a waste deposit site incurs in logistical costs.

### 5.1.4 Specific opportunities

Specific ***opportunities*** that were found and confirmed during this study:

- CNSL for local use as a **substitute for DDO/LFO, or as a base for paints or coatings** is more profitable than for export; logistical costs are relatively high for CNSL and DDO (linked to the fuel prices is an imported energy commodity and relatively high; for each country the opportunity depends on the local market demand, but conditions for local uses are promising). The idea is in an exploratory phase in Africa, but currently applied in other cashew processing countries (India, Viet Nam, Brazil).
- The African countries that were assessed have similarities: an increasing **electrical energy deficit** and huge quantities of biomass waste. The biomass has the tendency to increase wherever agri-processing is rising , which is the case in these countries. The opportunity for energy production from biomass constitutes an increasing opportunity to supply the energy deficit with green energy – though the power potential is limited: in the case of generating 1MW, the electricity from biomass would be all consumed locally in most cases.
- One step further, substitution of conventional energy by green energy (either electrical, or thermic) contributes to the **reduction of carbon emissions**. Most of the countries have included the value addition of biomass and production of green energy in their National Development policies. Even more, the Intended Nationally Determined Contributions, concretized in the National Development Plans 2030, because of the Paris Agreement 2015, where the countries ratified the conventions, include specific objectives on the reduction of $CO_2$ emissions[lii].
- There are **hardly any incentives** for investments on green energy from biomass and specifically applied to the cashew by-products in the African countries, including uses of biomass for thermal purposes (as a substitute for firewood and charcoal). Although the Clean Development Mechanism could be a suitable financing instrument, up till now there are no cashew related projects approved under this Clean Development Mechanism. In Kenya there are a couple of biomass projects approved under the CDM.
- **Charcoal production** for the local market is a low cost, but also a low benefit operation. Selection of an appropriate site to carbonize will minimize disturbances due to fumes and smells. Conducive policies to encourage alternative biomass fuels to substitute wood could favorite investments in charcoal production – as it is the case in Kenya, where cutting wood for charcoal production has been forbidden.
- For the small units there are a **couple of technologies available** (pyrolysis, gasification, charcoal production), where pyrolysis and charcoal production seems to be the most appropriate technology. Gasification for electricity purposes means foreign equipment, higher capex and operation than a pyrolizer, needs technical competences, which are expensive and rarely

available. A proven technology working for low capacities is the steam machine; however, maintenance costs should be managed. Efficiency of these machines is low, but they are sturdy. Cost per installed kW of steam machines is generally higher than gasifiers, so production costs of energy are bigger. As the experience in Guinea-Bissau shows, training of the operators is a must.

## 5.2 Recommendations

### 5.2.1 The government and para-public sector

Recommendations towards **governments and the para-public sector**:

1. In most countries, the concentration of processing and supply of shells for by-product needs to develop first in order to **secure supply of shells** for viable CNSL production and co-generation. There is already enough "critical mass" of concentrated shells in most of the countries. If national policies allow, and this is to a certain extent, it would be to envisage that the electricity would not be injected to the grid but sold directly to captive clients - which would be less complicated to manage and get permissions.
2. Enhancing **applied research** on the adaptation of technologies for the cashew by-products and alternative (local) applications of the derivates. There is still a lot of knowledge to develop around the uses of CNSL as a pesticide, or as a material for construction, or coatings. For the testa, local uses could include their addition in tea blends, or vegetable tanning. Finally, the discarded kernels have not the place they deserve in the cattle and poultry feed habits in African countries.
3. Spreading the **existing knowledge by exchange**: ways to derive value from discarded kernels or peelings, appropriate technologies to manage the environmental impacts of exhaust gases and process water.
4. Improving **investment climate** for waste recycling; considering the weak competitive advantage of the cashew sector in African countries in relation to cashew production in Asian countries and the energy potential of cashew waste, favorable incentives on investments for green energy would fit in the national policies of greening the economy.
5. Enabling the **CDM financing instruments** for the biomass-to-energy projects. This could also leverage commercial capital from investment banks or local banks to invest in this specific sector. As these investments contribute to production of green energy and carbon emission reduction, it enhances the green image of investors.
6. Investments contributing to **local energy production** can also be oriented towards co-generation projects. Therefore, policies and legal frameworks for local energy production and distribution need to be clear and attractive. Particularly in West African countries, where the co-generation case is identified as an opportunity, the policies are still in an emerging stage. This delays investments and discourages commitment from the private sector.
7. On institutional (governmental) level, there should be a **coherent vision and strategy** on cashew by-products. Individual Ministries should enlarge the scope on the cashew by-products.
8. Carbon emission reduction, due to the processing of the cashew by-products, contributes to the **Intended Nationally Determined Contributions** of the reduction of carbon emissions of the Paris Agreement. Governments' engagements will be assessed within the horizon of 2030 by the UNFCCC.
9. Cashew by-products should be considered at the **design stage** of a new cashew processing unit. For it to become a trend, joint efforts with national authorities are to be realized. If national environmental bodies and those representing agri-processing industry have knowledge on the technologies for cashew by-product processing, they would help create the conducive environment for an establishment of this parallel cashew industry. The shared knowledge on best practices should also reach them.

### 5.2.2 The sector organizations

Generally, national cashew sector (processors) associations are the most indicated bodies to be the sector sparring partner on the by-product issue. They should have a direct interest in terms of increasing competitiveness of the cashew sector, by raising awareness and facilitate investments in the by-products field, which will attract a variety of stakeholders and ultimately become a factor of stability for the processing sector. These institutions can precise the agenda to unlock the potential of cashew by-products. The findings of this study can contribute to the agenda.

Recommendations towards **sector organizations** on national (and regional) level:

1. Facilitate **exposure** to and **exchange** on the technologies for processors and governmental bodies and stimulate interactions to come to the best by-product solutions in the specific context. Recommendations for an exposure and training plan are presented in Annex 9.
2. **Provide an assessment** of the energy and carbon emission reduction at national and even regional level
3. **Reform** of the national cashew sector agencies so that support to processors becomes a priority, and the focus on by-products is given as means to secure financial stability.
4. In most countries, **legislation** is being (or has recently been) developed **to protect the cashew processing sector**. The variety of measures adopted is large: tax exemptions, fiscal and/or technical support to establish a new unit, facilitation of imports for processing equipment. In principle, any economic activity related with cashew by-products would not benefit from these incentives (for example, establishment of a CNSL extraction unit, or a briquette manufacturing unit from cashew shell cake). It would be advisable to **advocate for an extension of these measures to the by-products**; this would give a strong message that the public sector is committed to harness the maximum potential from cashew.
5. For this, **the public bodies should be aware of the potential**: The good news about cashew by-products is that processing is profitable even at a local scale. This means that the benefits (economic, social, environmental) are more than the export alternative, because they “keep the wheel running” in different value chains, apart from cashew.

### 5.2.3 The private sector actors

Recommendations towards the **private sector actors**:

1. **Explore** the different available solutions for by product development. Technologies and business case scenarios have been developed (besides the destination of direct burning in boilers, either at 100% or in a mixture with another biomass):
    a. CNSL extraction and export
    b. CNSL extraction and application in fuel blends for industrial burners and engines
    c. H2CP pyrolysis (gas for thermal use and charcoal)
    d. Gasification for co-generation (CHP[65]) for medium-scale factories VS steam machine
    e. Carbonization of shells or cake and the production of charcoal or briquettes
    f. Cardanol distillation unit
    g. Production of electrical energy and biochar via pyro-gasification
2. Be **compliant** with the environmental standards, as in all countries national policies and regulations prescribes mitigation measures. Specifically, for the cashew processing
    a. address air pollution, by not using directly cashew shells in the boilers for thermal energy; use a mixture with other biomass, use press cake from the CNSL unit or apply technologies as the H2CP (for vertical boilers) or a scrubber; a better control of the combustion by automation of the boiler (e.g. with automatic feeder) contributes also to complete combustion.
    b. Address water pollution, by the installation of a waste water treatment system

[65] Combined Heat & Power

    c. Deposing of shells should be timely and contamination with surface (run off) water must be avoided. This is possible with the ~~correct~~ appropriate infrastructure.
3. Conduct the **assessment** of the opportunity of energy from by-products:
    a. Economic benefits can be up to a value addition of US$125/Mt RCN
    b. Production of green energy (from the shells) contributes to the green image of the processing plant
    c. The reduction of carbon emissions reduces the carbon footprint of the processing activities and thus that of the entire value chain; progressive estimations indicate that a positive balance of carbon emissions is possible.
4. **Collaboration** between processors to create scale and a regular supply of shells for operation that require larger quantities: CSNL extraction and co-generation. Common investments or third-parties can be a next step. Private-public partnership seems to be a convenient setting for by-product investments, as the outcomes benefit private and public interest.
5. Finally, **investments** in by-product processing capacity, including the technical competence of staff.

### 5.2.4 The African Cashew Alliance

Recommendations towards the **African Cashew Alliance**:

1. ACA's position should be **catalyzing change**, by raising awareness and giving echo to all the ongoing by-product initiatives – and seeking for replication opportunities. Also help the factories to abide by the national regulations, because lack of observance can have a negative impact on the sustainability of cashew processing.
2. Adding value to by-products is in the first place a matter of **awareness**. In the countries where the institutions representing the cashew sector are too weak or inexistent, direct support from ACA to processors will be essential, though ideally the lead should come from the sectorial body. In general, the ACA is well positioned to work on a by-country basis with each of the relevant entities, by implementing a support plan to strengthen their capacities and promote knowledge sharing.
3. Develop a specific cashew by-product **policy** with the necessary instruments and facilitation of incentives for the ACA members
4. Support the countries' **sector associations/agencies** to improve their organizational abilities and strengthening the processors representatives. The ACA country representatives can play a role in this.
5. Develop **documentation on environmental impact reduction** methods, addressed to processors and environmental authorities.
6. Integrate the assessment of energy from biomass and carbon emission (reduction) into the assessment criteria of the **ACA seal**.

## 5.3 Critical success factors

As critical success factors are defined as crucial assumptions to develop the cashew by-products:

- Stability of RCN procurement for processors. Prices vary ± 40-50% during the campaign. The potential 10% on value addition of by-products is important, but the stability of the RCN supply is indicated in all countries as the highest priority.
- A common perception between private and public stakeholders on an integrated approach and strategy. From the public side, contribution on the development of energy policy and regulations regarding electricity supply and feed-in tariff, R&D on technologies and the compliance and development of CDM projects and carbon emission offset can be provided. This includes also capital in the form of grants and sales of carbon credits. From the private side, investment capital for by-product investments and incorporation of the energetic and environmental benefits into the corporate responsibility of the company.
- Some technologies are not widespread in Africa, and some do still need R&D for further development of prototypes and upscaling. This is a precondition for the viability of the business cases of the solutions.

## 5.4 Action plan proposal and cost estimation

For the direct follow-up of the main recommendations by the ACA a couple of action points and a tentative budget are proposed.

### 5.4.1 Actions

Immediate **communication** and exchange:

- Establish a specific policy on ACA level on by-products, with realistic goals and an implementation plan. Actors (government, private sector and para-public organization) can refer to it as a guideline.
- The documentation of this study can be actively shared to the involved actors, on country level. As a follow up, country workshops can be held to establish a strategy on national level and to assess the opportunity of partnerships. An online web portal with documentation, experiences and exchange (in the form of Q&A) on technologies should be put in place.
- Away4Africa will avail a web portal with the assessment tools ‘CashUCalculator’ with indicative calculations and scenarios that will support informed decision making, for the private sector and governmental bodies. This tool can be used for awareness and training.
- Exposure to existing and available technologies, in the form of country workshops. This should be sector driven and preferable private led. There must be an identification of priorities of specific themes or technologies that logically fits into the sector policy.

**Crucial factors** and actions for follow-up and monitoring:

- Facilitate and enable the country sector associations to take responsibility on the by-products. Firstly, the key responsible body is the country sector organization or the representative body for processors of the respective countries. The cashew by-product issue is an issue that needs to be addressed as a (processing) sector, and preferably not exclusively by individual factories. ACA's role can be more appropriate as a "catalyst for change", by creating and spreading the knowledge, and even coordinating technical workshops/trainings; broadcasting the good practices, facilitating investment and funds for development of solutions for by-products; but not being in the head of the development activities. An idea of “vouchers” can be launched. ACA emits vouchers to the sector organizations. The vouchers can be exchanged for technical assistance at preselected service providers on by-products. ACA can set the criteria for the sector organizations and the contractors. This private led initiative can be facilitated by the ACA, where it is only an intermediate body between contractors and cashew sector.

- Better creating the good environment for the country actors to work on development, not necessarily with ACA funds, though it is always an option. But at least that ACA is involved in looking for the necessary funding, the good linkages with countries' institutions
- Further assessment of the by-product situation should be done. More precise estimations and modelling of options of individual factories and the cashew sectors can be done, with the tool CashUCalculator. Standardized reports are provided on the modeled options and this allows comparison of between by-product situations and the choice of by-product processing. With the tool, current situation of individual factories, and at sector level can be identified the KPIs. Projections can be simulated by modelling of scenarios. It must be considered that it is a model that gives indications. Precise calculations on business cases should still be done. More detailed business case development, taking into consideration the specific context of proposed solutions can be elaborated. Partnerships (B2B) can be created and facilitated for realization of projects and investments.
- Monitoring of developments of investments in by-products, and more important, monitoring of the KPIs on economic, energetic and environmental impact. Particularly, on the environmental impact the offset of carbon emission reduction needs attention.
- Thirdly, on that basis, a request for exposure and training on the explanation of technologies can be done. This can be facilitated by Away4Africa and Fúnteni Installations et Conseil.

### 5.4.2 Tentative budget

A tentative cost estimation includes:

- Country workshops, under the responsibility of the sector associations: 8 x US$5,000
- Communication: development of a practical web portal, where information can be consulted by stakeholders, and where interaction is facilitated and stimulated: US$10,000
- Specific first program for R&D on testing and scaling up of technologies: US$50,000
- A follow up meeting on best practices with main stakeholders, after 1 year: US$10,000
- Monitoring of by-product investments and KPIs: US$10,000

NB. Budget estimations are based on external services delivered to the ACA, regardless the available capacities that the ACA team might have. The budget estimations do have an indicative timeframe of 1 year.

# 6 ANNEXES

## Annex 1. List of institutions and factories met and involved

| Name | Organization | Country | Capacity (Mt RCN/yr) |
|---|---|---|---|
| Tolaro Global | Factory | Benin | 6,000 |
| Afokantan Benin Cashews SA | Factory | Benin | 1,500 |
| Fludor Benin SA | Factory | Benin | 15,000 |
| FENAPAB | Sector association | Benin | |
| Nad & Co Industry | Factory | Benin | 1,000 |
| Technoserve | Sector association | Benin | |
| CNTC | Sector association | Benin | |
| IFA (Interprofession de la Filière Anacarde) | Sector association | Benin | |
| Anatrans | Factory | Burkina Faso | 5,000 |
| ANTA | Sector association | Burkina Faso | |
| Gebana SARL | Factory | Burkina Faso | 1,500 |
| Wouol Association | Factory | Burkina Faso | 6,000 |
| Sotria-B | Factory | Burkina Faso | 3,000 |
| Interprofression anacarde | Sector association | Burkina Faso | |
| TreeAid | NGO | Burkina Faso | |
| CAJOU DES SAVANES SA | Factory | Côte d'Ivoire | 5,000 |
| ABC | Factory | Côte d'Ivoire | - |
| AFRICA NEGOCE | Factory | Côte d'Ivoire | 2,000 |
| AFRICAJOU SARL | Factory | Côte d'Ivoire | 2,500 |
| AFRIQUE AGRI INDUDTRIE (2IA) sa | Factory | Côte d'Ivoire | 7,500 |
| AGROFRONAN | Factory | Côte d'Ivoire | 3,000 |
| CAJOU DE FASSOU | Factory | Côte d'Ivoire | 5,000 |
| CAJOU INDUSTRIE SA | Factory | Côte d'Ivoire | 2,000 |
| CILAGRI | Factory | Côte d'Ivoire | 30,000 |
| FMA | Factory | Côte d'Ivoire | 7,500 |
| Global Cashew Industries | Factory | Côte d'Ivoire | - |
| INC | Factory | Côte d'Ivoire | 5,000 |
| IVOIRE TAHANMAN INDUSTRIE (ITIA) | Factory | Côte d'Ivoire | 500 |
| NORD CAJOU | Factory | Côte d'Ivoire | 3,000 |
| OLAM | Factory | Côte d'Ivoire | 30,000 |
| OLAM | Factory | Côte d'Ivoire | 15,000 |
| PYRAM-CI SA | Factory | Côte d'Ivoire | 2,500 |
| ROMAF Sarl | Factory | Côte d'Ivoire | 100 |
| SITA | Factory | Côte d'Ivoire | 5,000 |
| SIVECCO | Factory | Côte d'Ivoire | 1,500 |
| SOBERY | Factory | Côte d'Ivoire | 2,000 |
| SOTRAPACI | Factory | Côte d'Ivoire | 7,500 |
| KAPPAGRI | Ministry | Côte d'Ivoire | 7,000 |

| Name | Organization | Country | Capacity (Mt RCN/yr) |
|---|---|---|---|
| AFRIQUE AGRI INDUSTRIES | Ministry | Côte d'Ivoire | 7,000 |
| CASA | Factory | Côte d'Ivoire | 7,000 |
| KIYO | Factory | Côte d'Ivoire | 3,000 |
| COCOPRAGEL | Factory | Côte d'Ivoire | 1,000 |
| COPABO | Factory | Côte d'Ivoire | 1,000 |
| IVOIRIEN DE NOIX DE CAJOU | Factory | Côte d'Ivoire | 10,000 |
| COOBABO | Factory | Côte d'Ivoire | 1,000 |
| GIC-CI | Sector association | Côte d'Ivoire | |
| CCA | Sector association | Côte d'Ivoire | |
| Anader | Sector association | Côte d'Ivoire | |
| COOPANAD | Cooperative | Côte d'Ivoire | - |
| COOPRAK | Cooperative | Côte d'Ivoire | - |
| UCOPAK | Cooperative | Côte d'Ivoire | - |
| COOPABO | Cooperative | Côte d'Ivoire | - |
| COOGES | Cooperative | Côte d'Ivoire | - |
| COOPRAMOVIT | Cooperative | Côte d'Ivoire | - |
| COPRODIGO | Cooperative | Côte d'Ivoire | - |
| EBOYOKUN | Cooperative | Côte d'Ivoire | - |
| Kelindjan | Cooperative | Côte d'Ivoire | |
| USCADD /COOPADEN | Cooperative | Côte d'Ivoire | |
| MIM Cashew | Factory | Ghana | 8,000 |
| Rajkumar | Factory | Ghana | |
| Usibras Ltd | Factory | Ghana | 15,000 |
| Ministry of Industry - Cashew desk | Ministry | Ghana | |
| Environmental Protection Agency | Ministry | Ghana | |
| Ministry of Energy - Department of Renewable Energies | Ministry | Ghana | |
| ACPG | Sector association | Ghana | |
| Clean Production Center | Ministry | Ghana | |
| ComCashew | NGO | Ghana | |
| SNV | NGO | Ghana | |
| BUSAC fund | NGO | Ghana | |
| Skill Development Fund | NGO | Ghana | |
| FUNDEI | Foundation | Guinea-Bissau | |
| Ministério de indústria | Ministry | Guinea-Bissau | |
| Ministerio de energia | Ministry | Guinea-Bissau | |
| Ministerio do Ambiente e Desenvolvimento sustentável | Ministry | Guinea-Bissau | |
| SANTY / WAC | Factory | Guinea-Bissau | 7,000 |

| Name | Organization | Country | Capacity (Mt  RCN/yr) |
|---|---|---|---|
| Emicor&filhos Sarl | Factory | Guinea-Bissau | 250 |
| Laïco industries | Factory | Guinea-Bissau | 1,000 |
| LICAJU | Factory | Guinea-Bissau | |
| SICAJU | Factory | Guinea-Bissau | 1,200 |
| Arrey Africa SARL | Factory | Guinea-Bissau | 3,500 |
| ANCA-GB | Sector association | Guinea-Bissau | |
| CAIA | Government | Guinea-Bissau | |
| PRSPA - World Bank | Foundation | Guinea-Bissau | |
| Abhay Engeneering | Manufacturer | India | |
| cashewinfo.com | Sector association | India | |
| Jungle nuts | Factory | Kenya | 5,500 |
| Kenya Nut Company | Factory | Kenya | 10,000 |
| Millenium management ltd. | Factory | Kenya | 7,500 |
| Equatorial nuts | Factory | Kenya | 3,000 |
| Wonder Nuts | Factory | Kenya | 4,000 |
| Nut Processors Association of Kenya | Sector association | Kenya | |
| ADPP | Factory | Mozambique | 50 |
| Aga Khan foundation | Institution | Mozambique | |
| Caju Ilha | Factory | Mozambique | 10,000 |
| Caju Ilha | Factory | Mozambique | 14,000 |
| CN caju | Factory | Mozambique | 1,000 |
| Condor anacardia | Factory | Mozambique | |
| Condor caju | Factory | Mozambique | 6,000 |
| Condor nuts | Factory | Mozambique | 10,000 |
| Emaju Lta | Factory | Mozambique | 50 |
| Indo Africa | Factory | Mozambique | |
| Jab Moz | Factory | Mozambique | |
| Korosho (ETG) | Factory | Mozambique | 10,000 |
| Korosho (ETG) | Factory | Mozambique | 7,000 |
| Mocaju LDA | Factory | Mozambique | 3,000 |
| Olam | Factory | Mozambique | 13,000 |
| Olam | Factory | Mozambique | 2,000 |
| Olam | Factory | Mozambique | |
| Sunny M. international | Factory | Mozambique | |
| TNS/Mozacajú | NGO | Mozambique | |
| INCAJU | Government | Mozambique | |
| INCAJU | Government | Mozambique | |

| Name | Organization | Country | Capacity (Mt  RCN/yr) |
|---|---|---|---|
| AICAJU | Sector association | Mozambique | |
| INCAJU | Government | Mozambique | |
| Ministry of Environment - Direcção Provincial de Meio ambiente | Government | Mozambique | |
| Ministry of Trade and Industry | Government | Mozambique | |
| Ministry of Mineral ressources and Energy - Direcção provincial | Government | Mozambique | |
| Ministry of Mineral ressources and Energy - Departamento de Energia | Government | Mozambique | |
| CFC common fund for commodities | Sector association | Tanzania | |
| Agrofocus (Newala I) | Factory | Tanzania | |
| ETG | Factory | Tanzania | 5,000 |
| Hawte foods | Factory | Tanzania | 1,000 |
| NARI Naliendele Agricultural Research Institute | Research | Tanzania | |
| Cashew Nuts Processors Association | Sector association | Tanzania | |
| Cashewnut Board of Tanzania | Government | Tanzania | |
| NEMC (National Environment Management Council) | Government | Tanzania | |
| Masasi High Quality Farmers products | Factory | Tanzania | 1,500 |
| Olam | Factory | Tanzania | |
| Perfect cashew kernels | Factory | Tanzania | 500 |
| Premier cashew | Factory | Tanzania | |
| Terra Cashew Processing Tanzania Ltd | Factory | Tanzania | 3,000 |
| YAMAMA Farms | Factory | Tanzania | |
| YYTZ Agro-processing | Factory | Tanzania | 2,500 |

## Annex 2. Detailed characteristics of the by products

**1. T-CNSL:**

| **Physiochemical properties** | | | |
|---|---|---|---|
| **Property** | **Units** | **Typical value** | **Method** |
| Appearance/color | - | Dark Brown Liquid | - |
| Specific gravity | g/ml | 0.92-0.96 | ASTM D891-B |
| Viscosity | cPs | 50-200 | Viscometer NDJ-5S |
| Ash content | Wt% | <1 | ISO 6338 |
| Moisture content | Wt% | <2 | ISO 662 |
| Loss in weight on heating | Wt% | <2 | |
| Acid value | mgmKOH/gm | <20 | ASTM D974 |
| Insolubles in Toluene | Wt% | <1 | ISO663 |
| Iodine value | - | | |
| Polymerization time | min | >4 | |

Source: Anatrans, 2014

**2. Cashew kernel oil:**

| Property | Result |
|---|---|
| 1. Colour | Golden yellow |
| 2. specific gravity | 0.908 |
| 3. Acid value | 5.3 |
| 4. Free Fatty acid content | 2.6 |
| 5. Saponification value | 176 |
| 6. Ester value | 170.7 |
| 7. Iodine value | 67.8 |
| 8. % of Glycerol | 9.34 |


Source: Mim Cashew, Brong Ahafo, Ghana. (by Murali Krishna Vinjamuri )

**3. Composted testa**

| | |
|---|---|
| Matière organique % | 48,39 |
| Carbone % | 28,06 |
| Azote total % **N** | 1,81 |
| C/N | 15 |
| Phosphore total g/kg **P** | 3,03 |
| Potassium total g/kg **K** | 5,88 |
| Nitrate ($NO_3$) mg/kg | 401,63 |
| pH eau | 6,25 |

Source: Gebana Afrique (lab analysis by Bureau National des Sols du Burkina)

## Annex 3. A summary of by-product markets and clients

| Product | Market | Client | Price/delivery | Examples |
|---|---|---|---|---|
| **T-CNSL** | International | Phenolic compounds industry and cardanol manufacturers | US$300-350 /Mt FOB | • Cardolite<br>• Alkyde industry<br>• Epoxy manufacturers |
| **T-CNSL** | Local/national | Local industry with burners (substitute for DDO/LFO) | 50-80% of the actual fuel price | Industries with boilers and furnaces : breweries, bakeries, steel manufacturing… |
| **Shells** | Local/national | Industries with fuel needs for heat | 10-15 USD/MT | • Thermal conversion through pyrolysis reactor (H2CP)<br>• Small industry<br>• CNSL processors |
| **Friction particles (from t-CNSL)** | Nigeria, and International | Manufacturers of friction materials (e.g. brakes) | To be determined | Road Master LAGOS |
| **Testa** | Leather tanning industry (local & international)<br><br>Pharma-chemical industry (international) | International fashion brands (SCADA, Adidas,…) using innovative and eco-friendly leather<br><br>Poutry growers (bed)<br><br>Pharma-chemical industry (extraction of anti-oxidants for cosmetics and food industry) | Given for free to local tanners (Kenya)<br><br>Dried testa for cosmetics (India) 615 USD/MT | Alisam Products (Kenya)<br><br>Catechins cosmetics |
| **Rejected kernels** | Local/national | Breeders or animal feed mix manufacturers | CFA 50-200 per kg | Local clients: Breeders of cows, pigs, poultry (reference: Burkina Faso) |
| **Discarded bits** | Local/national | | CFA 60 to 100 per kg | Local clients: poultry breeders |
| | | | | |
| **Indirect** | | | | |
| **Fuel for electricity** | Local/national | Electricity companies OR Independent Power Producer | | Côte d'Ivoire, Benin (both in project phase) |
| **Charcoal and briquettes** | Local | Fuel for domestic use | CFA 70 to 100 per kg | Local use of shell charcoal in domestic furnaces |
| **De-oiled shell cake** | Local/national | Fuel for boilers and furnaces | 20-30 USD/MT | Cement factory Benin |
| **Carbon offset** | International | To be determined | 8-12 USD/t$CO_2$ | |

## Annex 4. Case of gasification in India with use of cashew shells (from drum roasting)

As there are many gasifier manufacturers available, gasifiers are being progressively installed in these units. Gasifiers are also used to fire kitchens in community kitchens, like in factories restaurants, temples, or hotels. For example, since 2009 the Amrita Institute of Medical Science (Cochin, Kerala) is running its collective kitchen with a gasifier running on several types of biomass, including roasted cashew shells. Thanks to the switch to producer gas, the kitchens replaced 200kg LPG and 400 L diesel per day.

Heavy industries also are adopting gasifiers: it is the case of KMC Aluminium Industries (Coimbatore, Tamilnadu). The gasifier allows to replace the ancient fuel oil consumption.

*Figure 15. Gasifier set up at KMC Aluminum Industries*

Presently cashew process industry is discarding the drum roasting method and adopting the steam roasting method, following the instructions given by the State pollution control Board. From 2016, no new unit is allowed to open basing its process in drum roasting.

*Figure 16. Gasifier installed at Amrita Institute of Medical Science*[66]

[66] Source: ARYA engineering Ltd (Tamilnadu).

## Annex 5. Flue gases

Several conclusions can be drawn:

1. Emission rates of $NO_x$ and $SO_2$ can reach up to 75% higher values when using roasted shell compared to de-oiled cake to fire the Baby boiler (both $NO_x$ and $SO_2$ are responsible of the irritating nature of the flue gases, and have adverse effect on environment and human health).
2. Emission rates of phenolic compounds is 7 to 13 times higher when burning roasted shell, compared to de-oiled cake to fire the boiler; particulate matter values are more than 2 times higher in case of using roasted shell (when inhaled, phenolic compounds and particulate matter are persistent and cumulate in the lungs, causing health problems in the long run).
3. However, emission rates from phenolic compounds are very low, and cannot lead to values exceeding the OSHA[67]'s recommendation of <5 ppm phenols in workplace air (India does not have a specific threshold for phenols in ambient air).
4. Roasting process' emission rates are very similar to those of Baby boiler fired with roasted shells (except for NOx emissions, who are 5 times smaller for roasting process), but Roasting process emits bigger quantities of gases.
5. Hot air oven emissions (fed with roasted shell) are similar to those of baby boiler (fed with de-oiled cake); even if the de-oiled cake is a cleaner fuel, this is due to a small rate of shells fired in the oven, compared to the higher rate of shell cake.
6. Stack emissions from Roasting process are similar to baby boiler fed with roasted shell emissions

*Table 21. Stack emissions from several processing steps featuring combustion in small scale cashew processing units[68]*

| Source | Fuel | Gas flow rate [$Nm^3/h$] | Gas T [ºC] | $SO_2$ [$mg/m^3$] | $NO_x$ [$mg/m^3$] | Phenolic compounds[1] [$mg/m^3$] | Particulate matter |
|---|---|---|---|---|---|---|---|
| **Roasting drum** | Roasted shell | 1500-2500 | 135-360 | 10-36 | 27-131 | 2.9-5.3 | 665-1468 |
| **Baby boiler** | Roasted shell | 181-182 | 340-367 | 21-30 | 227-593 | 3.2-4.3 | 992-1270 |
| **Baby boiler** | De-oiled cake | 193-495 | 340-720 | 12-29 | 124-645 | 0.24-0.6 | 382-535 |
| **Hot air oven** | Roasted shell | 186-996 | 190-352 | 10-48 | 55-146 | 0.4-0.8 | 405-587 |

[1] Expressed as phenol ($C_6H_6O$)

[67] Occupational Safety and Health Organisation (US).

[68] Adapted from: Assessment of pollution load and preventive measures from cashew nut processing industries. *A. Srivastava and A. B. Akolkar (Central Pollution Control Board, 2010).*

## Annex 6. Environmental standards for cashew processing industry in India

As an illustration, below are the guidelines from Andhra Pradesh PCB for new cashew processing units.

General:

- The distance between the boundary of the site and boundary of any road shall be at least 100 m
- The minimum distance between the boundary of the site and human habitation (boundary of Town, Village etc.) shall be 1 km
- Total area of land acquired – Ac. 5.0
- On site emergency plan to be prepared before the activity is commenced i.e. before the trial production.

For units featuring drum process:

- To be located 1 km away from habitation
- No new units to be allowed in Palasa, Kasibugga & Mogilipadu clusters.
- Distance between 2 units shall be 500 m.
- A distance of 500 m shall be maintained between the boundary of site and the edge of National & State Highway.
- A distance of 100 m shall be maintained from boundary of site and edge of internal (i.e. not surfaced) roads in the Districts.

For units featuring Boiling Process:

- To be located 200 m away from habitation.
- No new units to be allowed in Palasa, Kasibugga and Mogilipadu clusters. However, new unit with boiling process will be allowed replacing sick unit in the said clusters where roasting process took place hitherto on submission of the proof of the existence of the old unit from any of the Government departments. Multiple new units in one premises, in place of one sick unit is not allowed.
- De-oiled cashew nut shell / bio-mass shall be used as fuel for the boiler and drier.

These guidelines are applied in the evaluation of the new units in project, in order to validate the Permission of establishment application.

Once the processing unit starts working, other regulations apply. The Environmental (Protection) Rules in its Schedule I sets emission standards for specific industrial sectors (each one having a serial number). In 2010 the Schedule I was amended to add serial number 103 – cashew industry. These standards are shown in Table 22 and Table 23.

Penalties for violation under the Environmental (Protection) Act and the rules issued thereunder shall be punishable with imprisonment (up to five years). Fines up to 10,000₹ are also an eligible punishment, and can be added or substitute prison. In the case of failure or contravention, the offender shall be punishable with additional fines (up to 5,000₹) and up to seven years' prison.

*Table 22. Gas emission standards for cashew industry*[69]

| Parameter | Process | Emission Standard Limiting concentration [mg/Nm3][1,2,3] |
|---|---|---|
| **Particulate matter** | Drum roasting | 250 |
| | Cooking (roasted shell/de-oiled cake as fuel) | 150 |
| | Borma oven heater (roasted shell/de-oiled cake as fuel) | 150 |
| **Stack height** | | Minimum [m][4] |
| | Drum roasting | 20 |
| | Cooking | 15 |
| | Borma oven heater | 15 |

Note: 1. All values of particulate matter shall be corrected at 4% $CO_2$.
2. Emissions from the dog house shall be channeled along with roasting drum emissions and pass through wet scrubber.
3. Bio-gasifier should be installed if roasted shell is used as fuel.
4. Each stack shall be two meters above the top highest point of the building or shed or plant of the industry.

*Table 23. Effluent standards for cashew industry*

| | Limiting concentration | | |
|---|---|---|---|
| | Inland surface water | Public sewer | Land for irrigation |
| **pH** | 6.5 to 8.5 | 6.5 to 8.5 | 6.5 to 8.5 |
| **Oil & grease, max [mg/L]** | 10 | 20 | 10 |
| **BOD 2 days 27°C, max [mg/L]** | 30 | 250 | 100 |
| **Suspended solids, max [mg/L]** | 100 | 600 | 200 |
| **Phenols, max [mg/L]** | 1.0 | 5 | -- |

According to information from Central PCB, the waste water quality parameters are, in most cases, above the thresholds (Table 24).

*Table 24. Water effluent from Quenching (Roasting process) and Cooking process*[70]

| Process | Flow rate | pH | Oil & Grease [mg/L] | BOD [mg/L] | Suspended Solids [mg/L] | Phenols [mg/L] |
|---|---|---|---|---|---|---|
| **Quench process** | 14-21 L/h | 7.2-8.2 | 1400-2068 | 2000-5424 | 1175-2115 | 5.2-7.0 |
| **Cooking process** | 0.8-5.0 L/100 kg RCN | 5.3-7.3 | 24-52 | 2800-5000 | 350-720 | 4.2-10.2 |

69 Adapted from The gazette of India, 1st January 2010

70 Adapted from: Assessment of pollution load and preventive measures from cashew nut processing industries. *A. Srivastava and A. B. Akolkar (Central Pollution Control Board, 2010).*

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