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Sustainable Sourcing of Indigenous West-African Seed-oils for Personal Care Applications

A case study on the supply chains of baobab and shea

Master's thesis in Industrial Ecology

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Cover:
The picture displays a baobab fruit pod hanging from a branch of the tree in focus with its digit-like green leaves in front of a blurred savannah background (Aduna, n.d.-a).

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ABSTRACT
Many West-African oilseeds are resources with untapped potential that could be attractive for the cosmetic industry, baobab (*Adansonia Digitata*) being one example. Shea (*Vitellaria Paradoxa*) is an already commercialised indigenous West-African species that plays an important role for rural livelihoods in the region. Some commonly mentioned sustainability aspects of increased utilisation of indigenous trees are the potential to contribute to the local communities and to the conservation of the species. However, since sustainability is a broad and widely used concept, it is important to define what sustainability really means in a specific context. The beauty industry, a growing multi-billion-dollar industry, is seeing intensified consumer demand for natural, clean, and sustainable products. As a result, cosmetic ingredient producers such as the German specialty chemical company Evonik, are investigating new potential raw materials to stepwise transform their product portfolio. The purpose of the study is thereby to investigate how commercial activities can be combined with socio-ecological engagement when sourcing and integrating bio-based feedstock in an industrial supply chain. The aim is to, through a case study on baobab and shea, investigate the feasibility and sustainability of sourcing West-African indigenous seed oils as raw materials for cosmetic oils and fatty acids.

The project is conducted as a case study using methods such as the product chain organisation study (PCO) and material flow analysis. The PCO enables identification of technical process steps, actors and their role and scope of action in the product chain. The actors' perspectives on sustainable and ethical sourcing are collected through semi-structured interviews. These perspectives, together with study areas from conventional feasibility studies, creates the foundation for an assessment framework. The framework consists of a set of study areas, for which critical questions and criteria are formulated. As a result, 17 study areas and 38 criteria are identified to guide the initiation of feasible and sustainable sourcing.

For sourcing baobab and shea as raw materials for cosmetic ingredients, some criteria are already met while others require further activities to be met. The oil processing of baobab highly depends on the oil yield which in turn impacts its applicability as feedstock for cosmetic ingredient manufacturing. The perspectives on sustainable and ethical sourcing both differ and align among the actors involved. Therefore, there is a need to identify what sustainable and ethical sourcing mean for the actors within the product chain. The criteria identified in this study can be used to define what sustainability really means in the specific area of sustainable sourcing. It is evident that sustainable and ethical sourcing are not just "nice to have", but fundamental to do business. The sourcing scheme suggested in this study presents an opportunity to engage in an unconventional sourcing scheme with unconventional partnerships around unconventional seed-oils with potential to create a positive impact to both people and planet.

Keywords: Indigenous seed-oil, sustainable sourcing, ethical sourcing, product chain organisation study, PCO

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List of Abbreviations

ABS	Access and Benefit Sharing
ABSCH	The Access and Benefit-sharing Clearing-House
B2B	Business to Business
CBD	Convention on Biological Diversity
CBE	Cacao Butter Equivalents
CBI	Centre for the Promotion of Imports from developing countries
CPFA	Cyclopropenoid Fatty Acids
EIA	Environmental Impact Assessment
ES	Ecosystem Services
FA	Fatty Acid
FFA	Free Fatty Acid
FAF	Feasibility Assessment Framework
FAO	Food and Agriculture Organization
FFA	Free Fatty Acid
GSA	Global Shea Alliance
GGW	Great Green Wall
GGWSC	Great Green Wall Sourcing Challenge
HDI	Human Development Index
IBBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IE	Industrial Ecology
IPPMC	Integrated Project Planning and Management Cycle
KPI	Key Performance Indicator
LCA	Life-Cycle Assessment
MFA	Material Flow Analysis
NCP	Nature's Contributions to People
NFP	National Focal Point
NGO	Non-Governmental Organisation
NTFP	Non-Timber Forestry Product
PCO	Product Chain Organisation Study
SDGs	Sustainable Development Goals
SLM	Sustainable Land Management
SME	Small and Medium-sized Enterprise
TELOS	Technical, Economic, Legal, Operational and Schedule
TFM	Technical Flow Model
TfS	Together for Sustainability
UEBT	The Union for Ethical BioTrade
UN	United Nations
UNCCD	United Nations Convention on Combatting Deforestation
UNDP	United Nations Development Program
UNIDO	United Nations Industrial Development Organization
UNCTAD	United Nations Conference on Trade and Development
WWF	World Wildlife Foundation
WHO	World Health Organisation

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Kristine Ahlborg Delvin
Tove Jensen
Gothenburg, June 2021

1 Introduction

In this chapter, the rationale of this report is described by presenting the aim and purpose of the study, corresponding research questions and limitations. This is followed by a brief description of the report structure.

1.1 Background

Many West-African seed-oils are resources with untapped potential that could be attractive for the beauty industry (Lykke et al., 2021). The beauty industry, a growing multi-billion dollar industry that includes cosmetics and personal care products, is seeing intensified consumer demand for new products that are natural, clean, and sustainable (Danziger, 2019). For industries such as the beauty industry that rely on chemical ingredients, biomass is one of few available feedstocks that can replace fossil-based feedstocks (Stegmann et al., 2020). The foundation to biomass and biobased resources is our nature. Nature contributes with everything from food, materials, and genetic resources that can be used for various applications such as personal care products (IPBES, 2019). The increasing consumer demand for natural and sustainable cosmetics is a driving force for actors like the German specialty chemical company Evonik Industries AG to investigate new potential feedstock. In line with this trend, the business line Evonik Care Solutions has started to stepwise transform their product portfolio which requires an integration of new sustainable raw materials. Care Solutions is therefore looking into sourcing sustainable bio-based feedstock on an industrial scale for the production of cosmetic ingredients. In fact, the ambition is to source new feedstock in a way that combines commercial interest with socio-ecological engagement.

Despite showing good potential for increased usage and application in the cosmetics industry, there are several barriers for implementing West African Seed-oils in industrial processes. The general barriers highlighted by Lykke et al. (2021) relate to the limited scientific data available on fatty acid content, difficulties in meeting international standards from local production, and the low knowledge of these seed oils. The final barrier is the difficulty to establish continuous supply chains between the local producers and international buyers. In addition to these barriers, there might also be challenges to source seed-oils sustainably. But what does sustainable sourcing of indigenous seed-oils actually mean?

Today, the words sustainability or sustainable are widely used by governments, companies, and individuals to describe policies, products, and services with widely different functions and applications (Hedenus et al., 2018). Therefore, it is important to define and understand sustainability for the area of application. Some commonly mentioned sustainability benefits of using indigenous plant species are the potential contribution to local communities and the conservation of the species (Lykke et al., 2021; Vermaak et al., 2011).

In the Sahel and other rural parts of Africa, many communities rely on non-timber forestry products (NTFPs) for their livelihood and survival (Schumann et al., 2012; Venter & Witkowski, 2013). Within the Sahelian and Sudanian savannas, baobab

(Adansonia Digitata L) and shea *(Vitellaria Paradoxa)* are two important examples of trees that provide NTFPs such as food, medicine, materials, and additional income from trade (Boffa, 2015; Diop et al., 2006). These trees commonly grow in the wild or close to agricultural sites and settlements providing products and shelter for livestock, wild animals, and people (Boffa, 1999). Research shows that increased utilisation and commercialisation of NTFPs can improve livelihood for cash-poor, rural communities, through e.g., income generation for women and conservation of the tress (Poole et al., 2016). However, the land in which both baobab and shea are found is threatened by increased desertification and degradation (UNCCD, 2019).

To fight desertification of the Sahelian and Sudanian savannahs, the pan-African initiative Great Green Wall (GGW) works to reforest land in the Sahel through integrated ecosystem management, varied land use, and restoration of drylands and natural vegetation (UNCCD, 2021). One of the few private actors involved in GGW is the United Kingdom based small medium-sized enterprise (SME) Aduna Ltd. Aduna collaborates with ORGIIS, a local NGO operating in the areas of the Upper East region of Ghana and Centre-Sud Burkina Faso. Through their collaboration, around 1800 small-scale women producers are engaged in the supply chain of Aduna's superfood product: the baobab fruit. Currently, only the pulp from the baobab fruit is sold to the international market. The seeds are under-utilized and have the potential to create a new value chain from the baobab fruit. Shea is a commercialised indigenous West-African species that plays an important role for rural livelihoods. Many things can be learnt from the existing shea supply chain, and it is interesting to analyse how shea could be integrated in the Aduna baobab pulp sourcing platform. Now, Evonik and Aduna want to join to enable sustainable sourcing of baobab seeds and shea kernels as a potential raw material for cosmetics ingredients. By adding value to the two indigenous species, shea and baobab., they can together contribute to reforestation of the Sahel as well as generate increased income for local communities.

1.2 Purpose and Aim

The purpose of this study is to investigate how commercial activities can be combined with socio-ecological engagement when sourcing and integrating bio-based feedstock in an industrial supply chain. The aim is to, through a case study, investigate the feasibility and sustainability of sourcing baobab and shea as raw materials for cosmetic oils and fatty acids.

1.3 Research Questions

The following research questions were defined:

RQ1: What does the product chain organization (PCO) of a bio-based cosmetic ingredient look like?
RQ2: How does the perspective on sustainable sourcing differ and align among the main actors of the product chain?
RQ3: What case specific study areas and criteria should be used to assess the sustainability and feasibility of baobab and shea when used as cosmetic ingredients?
RQ4: According to these criteria, how can it be considered sustainable and feasible for Evonik to source baobab and shea as raw materials for cosmetic ingredients?

By answering these questions, this master's thesis intends to provide a good foundation for Evonik and Aduna to decide if and how the sourcing of baobab and shea as raw materials for fatty acids and cosmetic oils can be considered feasible and sustainable.

1.4 Limitations

This master's thesis investigates seed-oils from two specific types of West-African indigenous trees, baobab, and shea from the geographical region of Ghana and Burkina Faso. The upstream activities related to the production of cosmetics and personal care products by Evonik will be in focus, meaning that the study is "cradle-to-gate". All activities within and after Evonik's operation e.g., consumer use, are considered out of scope in this study.

The analysis will mainly assess the current state of the supply chain including an identification of new actors, process steps, and flows needed to supply baobab and shea fatty acids and cosmetic oils on industrial scale. In this study, cosmetic oil is not only a cold pressed oil, but technology is added to the oil to refine its properties suitable for a personal care product. When reading this report, it is therefore important to note the difference between "oil" and "cosmetic oil", the latter being the final product.

The two species baobab and shea have different roles in this study. Baobab based seed-oil is currently unconventional and not produced at large industrial scale. Shea on the other hand is commercialised. Both shea butter and shea based fatty acids are produced on industrial scale for personal care applications. Therefore, how to sustainably scale up the production of baobab seed-oil creating local benefits will be the focus. As shea is currently more commercialised it is used as a benchmark and reference. The final sustainability and feasibility assessment is carried out for baobab.

The economic feasibility in terms of cost and prices along the product chain will not be evaluated in this study. These aspects are important for the feasibility but will be investigated as a next step outside the scope of this thesis.

The technical feasibility in terms of chemical applicability and functionality of baobab and shea is not covered in this study. However, it is an important part of the technical feasibility for the realisation of sourcing baobab and shea. Evonik is therefore conducting a study in a lab environment simultaneously with this study to determine the functionality of baobab and shea oil as fatty acids in the cosmetic ingredients. This is a part of the pilot study further explained below. Until the result of this study is finalised, this master's thesis assumes that baobab seed-oil is chemically feasible as a raw material. Shea is already used in cosmetics and is therefore considered chemically feasible. Moreover, it is assumed that some already available fatty acid producer can in fact produce fatty acids from baobab oil and shea butter. Currently, no fatty acid production for baobab oil exists and the production commonly requires large industrial sites for economic feasibility.

In connection with this master's thesis, a pilot study has been initiated to establish a better understanding of important parameters and characteristics of the baobab seeds from the specific geographical area under investigation. The pilot study will investigate aspects like oil yield, oil processing parameters and later fatty acid content to mention a few examples. The pilot study involves a pressing facility in Ghana and will also

provide insights related to one of the barriers mentioned in the introduction i.e., quality of locally produced oil.

1.5 Report Structure

This report begins with theory in Chapter 2 that presents sustainability perspectives and feasibility concepts as this master's thesis aims to assess the sustainability and feasibility of sourcing a wild-harvested raw material as a cosmetic ingredient. Furthermore, the theory chapter covers non-timber forestry products (NTFPs), nature's contribution to people (NCP), and biodiversity as well as a brief description of bio-based oils and fatty acids in cosmetic industry. In Chapter 3, the method of the study is presented through a description of the workflow and the different tools used. Chapter 4 presents detailed information about the geographical region, actors and the current sourcing platform that are important parts of the case study. Moreover, baobab and shea are thoroughly described to provide knowledge of the trees, their fruit, and their contributions to people.

Chapter 5-7 entails a combination of results and analysis following the research questions defined in Section 1.3. Chapter 5 presents the PCO for a cosmetic ingredient based on a wild-harvested raw material. Within the PCO, the technical flow model, the material flows, and the direct and indirect actors involved are identified and presented. The perspectives on sustainable and ethical sourcing of these identified actors are presented in Chapter 6. In Chapter 7, the results from the earlier chapters are used to identify study areas, information needed within each study area, and related criteria for each study area. These study areas and criteria creates an assessment framework. The assessment framework allows an evaluation of how commercial activities can be combined with socio-ecological engagement through a case study of baobab and shea as cosmetics ingredients. A discussion of the results, implication to research and further recommendations are presented in Chapter 8. Lastly, the research questions are revisited and evaluated in Chapter 9 together with key insights and a final comment.

2 Theory

In this section, theory is presented to give a good foundation for the case study, results, and analysis. More specifically, the concept of sustainability is described to provide an understanding of the broad set of definitions and perspectives related to the subject. The definition of feasibility along with a set of feasibility frameworks are also presented. The broad topic of nature and its vital contributions to people is also included. Lastly, a brief description of bio-based oils and fatty acids is included to create the connection to applications in personal care products.

2.1 Sustainability

The most common definition of sustainable development is the classic description from the report Our Common Future by the World Commission on Environment and Development (1987) as "*the ability to meet the needs of the present without compromising the ability for future generations to meet their own needs*". The so called Brundtland-definition includes both inter-generational and intra-generational equity and has the ultimate aim of meeting human needs. Furthermore, it divides sustainable development into three dimensions of economic sustainability, environmental sustainability, and social sustainability. Despite its widespread acceptance, the Brundtland definition has been both criticized and praised (Palme, 2007). During the last three decades, several other definitions have emerged that captures the multitude of perspectives that exist on sustainable development and sustainability.

Another definition of sustainability is the four socio-ecological principles and related indicators proposed by Azar et al. (1996). These principles are based on the rationale that since sustainability was non-relevant until the existence of non-sustainability caused by human activities, the system conditions for sustainability should be framed as restrictions (Holmberg & Robèrt, 2000). The first three principles are based on the concept of what society must not systematically do to nature, while the fourth addresses how natural capital should be distributed in society. The four principles of a sustainable society are to ensure that:

i. … nature's functions and diversity are not systematically subject to increasing concentrations of substances extracted from the Earth's crust
ii. ... nature's functions and diversity are not systematically subject to increasing concentrations of substances produced by society
iii. … nature's functions and diversity are not systematically impoverished by over-harvesting or other forms of ecosystem manipulation
iv. … resources are used fairly and efficiently in order to meet basic human needs worldwide.

Meadows (1998) presents another framework for sustainable development suggested by the Balaton Group, depicting the relation between human well-being, economy, technology, and natural capital as ultimate ends and means and intermediate ends and means as seen in Figure 1. The framework suggests that natural capital is the ultimate means to life on our planet. Natural capital that ranges from genetic information in small organisms to geochemical cycles, is not created by humans but our heritage. Still, science and technology can convert the ultimate means into intermediate means i.e., convert natural capital into built capital and human capital. Here, labour, tools,

factories, and processed materials are considered intermediate means. In her article, Meadows (1998) criticizes how intermediate means such as machines and skilled labour are commonly considered as the inputs to the economy by economists, which ignores the fundamental need of nature's unpriced inputs. To go from the intermediate means to intermediate ends of human and social capital, politics and economics need to be involved in the management and valuation. Meadows (1998) argues that the intermediate ends are normally the goals that governments promise to deliver e.g., health, wealth, and knowledge and are commonly considered as the final output by economists. To go further to the ultimate end human well-being, ethics and theology are needed to understand what human and social capital such as goods and wealth are actually good for. Meadows further elaborates on the difficulties of defining human well-being, but mentions happiness, fulfilment, and community.

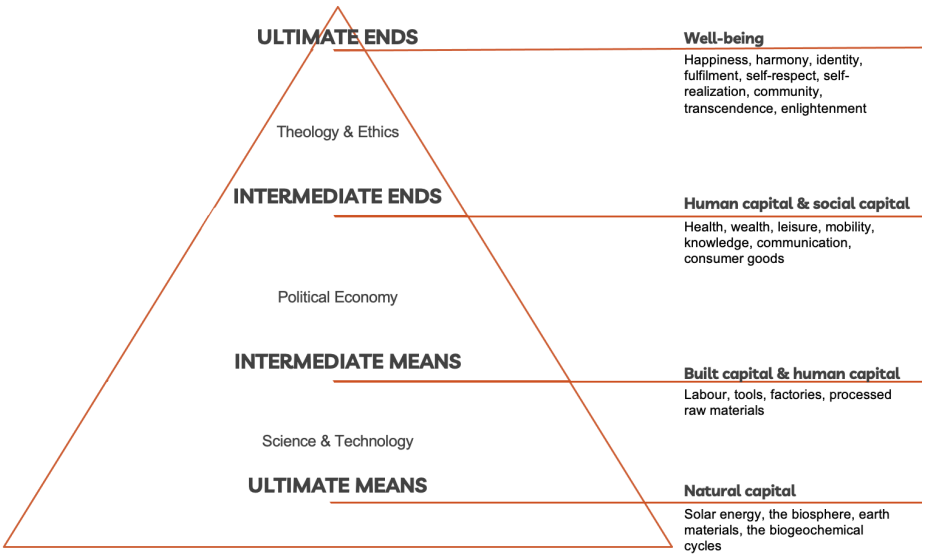


Figure 1 The conceptual model of sustainability adapted from the model suggested by Meadows (1998).

Another perspective of sustainability is the lighthouse model developed by Holmberg and Larsson (2018). Their conceptual framework is presented in figure 2. Its purpose is to drive dialogues for sustainability transitions through the four questions presented in the figure. The model shows how the lighthouse keep focus on human needs and well-being, asking the question "what is a good life?". The lighthouse rests on a foundation of ecological sustainability, by asking the question "how can society's activities fit within nature's carrying capacity?". Here, the exchange of materials between society and nature is in focus through the displacement of the ecosphere, reshaping of the ecosphere, and society's impact of processes and flows. For the social dimension, equality, trustful vertical relationships (between individuals and institutions) and horizontal relationships (between people) are in focus. For the economic dimension, the importance of asking ourselves "how can capital be managed for the future?" is stressed. Capital means material and immaterial stocks and are valuable assets for both present and future generations.

Figure 2 The lighthouse model as presented in Holmberg and Larsson (2018). Used with permission.

The Agenda 2030 for Sustainable Development can also be considered a perspective on sustainability. It aims to "*provide a shared blueprint for peace and prosperity for people and the planet, now and into the future*" (United Nations, 2021). Agenda 2030 builds upon decades of work by countries and the United Nations (UN) and was adopted by all UN Member States in 2015. The seventeen Sustainable Development Goals (SDGs) represents the core of the Agenda 2030 and are presented in figure 3. The SDGs have a strong foundation in the Brundtland-definition, while also taking a comprehensive approach to sustainability by covering seventeen goals for a sustainable society. Each goal is divided into targets for countries to achieve. Today, also businesses adopt the SDGs to monitor and communicate their sustainability impact.

Figure 3 The Sustainable Development Goals from Agenda 2030.

Having the complex task of defining sustainability in mind, it is understandable that assessing and/or integrating sustainability in decision making is not easy. As phrased by Hutchins and Sutherland (2008), one of the key challenges of sustainability is to make the Brundtland definition operational as a guidance to decision making. For the environmental dimension of sustainability, Finnveden and Moberg (2005) concludes that there are many tools available to assess environmental impacts. Life-Cycle Assessment (LCA), Environmental Impact Assessment (EIA) and Material Flow

Analysis (MFA) being just three examples. The economic pillar is already common practice for decision makers to address and environmental aspects are increasingly being incorporated. However, the social pillar has historically gained little attention compared to the other two. When discussed, it mostly includes human health and safety as well as more legislative issues rather than ethical and cultural aspects (Hutchins & Sutherland, 2008). Social LCA intends to assess social and sociological aspects of a product (UNEP, 2020). However, this approach is applied to a very limited degree by organisations according to a recent Swedish study (Lindkvist & Rydberg, 2020).

2.2 Feasibility

The word feasibility means "*the possibility that can be made, done, or achieved, or is reasonable*" (Cambrige Dicitionary, 2021). A feasibility study is commonly conducted in connection with a large investment or construction projects. There are several frameworks and approaches developed for these purposes. A few of these frameworks are described below and further details are presented in Appendix A.

Ssegawa and Muzinda (2021) describes the feasibility analysis or study as "*a management decision tool that assesses the viability of a project concept to enable an organisation to decide whether to go ahead with a project concept or to reject it and hence avoid wasting resources*". A feasibility study should also identify and evaluate alternative pathways and produce a recommendation whether to accept or reject a project concept. A feasibility study needs to be based on several study areas. Ssegawa and Muzinda, (2021) concludes that it is not possible to agree on a general set of feasibility areas applicable for all feasibility studies. However, the five areas Technical, Economic, Legal, Operational and Schedule (TELOS) are commonly used. These five areas are described in Appendix A. Depending on the nature of a project, a weighting of the feasibility areas can be needed to show their relative importance (Ssegawa & Muzinda, 2021).

In 1978, the United Nations Industrial Development Organization (UNIDO) released the first version of their "Manual for the Preparation of Industrial Feasibility Studies" (Behrens & Hawranek, 1991). The purpose of the initial publication was to provide a tool for developing countries to improve the quality of investment proposals as well as to contribute to the standardisation of feasibility studies. Before any investment, a pre-feasibility study, a feasibility study and potential supporting studies are recommended. A pre-feasibility study aims to assess the project idea before a full feasibility study is made. A pre-feasibility study can include supporting studies that analyses current of future raw material availability or covers an environmental impact assessment (EIA). The feasibility study should according to the manual include data in the five areas: commercial, technical, financial, economic, and environmental.

According to Goodman (1988), a feasibility analysis should be conducted when a project has a preliminary formulation and design to answer if the project is justified from different points of view. The feasibility analysis defined by Goodman (1988) can be part of an Integrated Project Planning and Management Cycle (IPPMC), and aims to answer five interrelated questions within six different study areas; technical, economic, administrative/managerial, environmental, social/political as well as financial. The detailed content of each study area is described in Appendix A.

2.3 The Value of Nature

Nature and the state of nature is a complex matter, difficult to imagine and to describe in words. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) refers to nature as the natural world with an emphasis on biodiversity (IPBES, 2019). In addition, the areas of ecosystems, ecosystem functioning, biosphere, humankind's shared evolutionary heritage, and biocultural diversity are also included in their definition of nature. In their latest global assessment report, IPBES (2019) summarises scientific research on how direct and indirect drivers are causing decline of biodiversity and ecosystem services. This decline threatens good quality of life for humans, as most of nature's contributions to people are essential for human health. In this section, the aspects of nature's contributions to people, biodiversity, and non-timber forestry products are covered as these aspects are directly linked to the sourcing of bio-based raw materials.

2.3.1 Biological Diversity

Our planet's biological diversity is the result of billions of years of evolution. The term biological diversity is defined in the Convention of Biological Diversity (CBD) as "*the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems*" (United Nations, 1992). Basically, biodiversity provides a large set of goods and services that forms the unique habitat where us humans live. Thus, biodiversity is fundamental as it form the "web of life" to which humankind fully depend (Secretariat of the Convention on Biological Diversity, 2000). The loss of the large set of biological diversity is also important to acknowledge as this can reduce the productivity of ecosystems and thereby also the goods and services that nature provides such as food, material, and genetic resources.

The Nagoya protocol was adopted to the CBD at the Conference of Parties in Nagoya, Japan as a supplementary agreement (Secretariat of the Convention on Biological Diversity, 2021c). The agreement regulates how genetic resources are collected, utilised in both research and product development, and how profits are distributed from this use. Within the CBD, genetic resources are defined as "*genetic material of actual or potential value*" and genetic material as "*any material of plant, animal, microbial or other origin containing functional units of heredity*" (United Nations, 1992). If access to a genetic resource or traditional knowledge is granted, it shall be over mutually agreed terms and be subject to prior informed consent by the providing party. In addition to flora and fauna, traditional knowledge of indigenous peoples and local communities with traditional lifestyles are also recognised within the protocol. Traditional knowledge incudes innovation, local knowledge and practices preserved through stories, legends, folklore, rituals, songs, and laws. What is defined as traditional knowledge is controlled by national Access-Benefit-Sharing (ABS) legislation from the country that provides the resource. Currently, the Nagoya protocol is adopted by 129 nations, ratified by one nation and non-ratified by 69 nations.

2.3.2 Nature's Contributions to People

The concept nature's contributions to people (NCP) is based on ecosystem services (ES) while integrating cultural values and the important role of social sciences as well as indigenous and local knowledge (Díaz et al., 2018). Therefore, there is a need to

briefly understand ecosystems and ecosystem services in order to fully understand NCP. An ecosystem can be defined as the interacting system made up of all the living an non-living objects in a specified volume of space (Weathers et al., 2012). An ecosystem service (ES) is a value-laden concept and can therefore be defined in various ways. Although, as Jax et al (2013) argues, the general accepted meaning of the ES concept is that ecosystems contribute to human well-being. The conceptual framework of ES is mainly based on economics and ecology that analyse stocks, flows and trade-offs of people-nature relationships. The ES notion has been criticized for being too Western, not taking aspects like "Mother Earth" into account (Díaz et al., 2018). This report will therefore, in line with the terminology of IPBES, use NCP as a notion to describe the many contributions that nature generates.

Within the NCP framework, nature can contribute to people's quality of life with both intrinsic values and instrumental values. In contrast, ES normally focus on quantifiable and generalizable values and therefore often loose context-specific values such as institutional, cultural and social aspects of land systems and especially issues of justice and power relations (Ellis et al., 2019). The NCPs are divided into material, non-material, and regulating contributions, that can be both positive and negative. Although, there is an overlap between the three contributions. Ellis et al. (2019) give the example of food to display the fluidity of the contributions, as food can be both a material contribution as well as a non-material one based on aspect such as rights, identity, and spirituality. In addition, IPBES divides the NCPs into 18 categories to which certain indicators are allocated with the purpose to measure and monitor NCPs (IPBES, 2019). The eighteen categories, contributions, and indicators are presented in Appendix B.

2.3.3 Non-Timber Forestry Products (NTFPs)

Non-timber forestry products (NTFPs) are most commonly defined as all biological materials other than timber which are extracted from forests for human use (Shackleton et al., 2011). NTFPs are often attributed with potential value for both forest conservation and income generation to rural communities by researchers and by international organisations such as IPBES, UNDP, and WWF (Shackleton & Pandey, 2014; Walker, n.d.). According to both Venter and Witkowski (2013) and Schumann et al. (2012), many rural communities in the semi-arid tropics usually rely on NTFPs for livelihood in combination with other income streams such as employment and grants. Land use intensification and degradation are threats to NTFP tree species and thus also a risk to local livelihoods and ecosystems.

Based on the research of Clay (2004), there are many potential economic returns to be gained by an improved NTFP efficiency. As visualised in figure 4, it is usually only a very small fraction of a product's value that goes to local NTFP producers. However, by locating processing and production activities closer to the NTFP source, gross income of local communities can be increased by 500%. Clay (2004) further highlights improved transport to processing plants as well as improved local storage as measures to reduce losses by 35% and 25%. The conservation concept of "nature pays" from the WWF utilises some of the measures mentioned as "tactics" for e.g., NTFPs value chain development aimed to support market access and bring more benefits to communities.

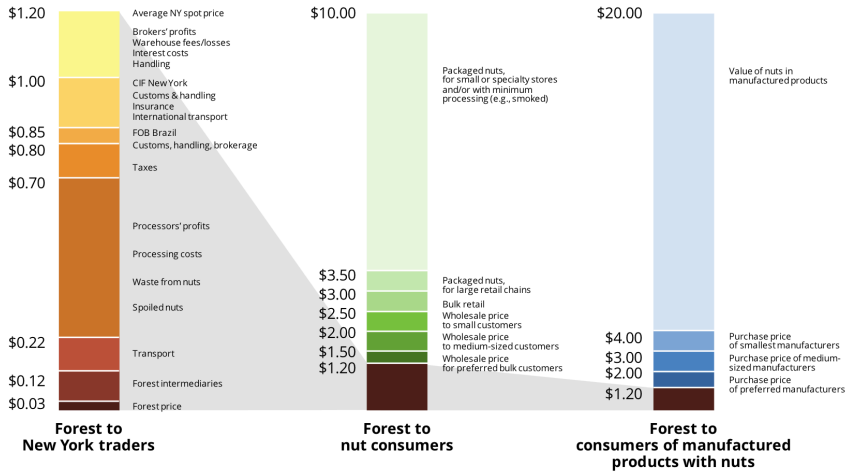
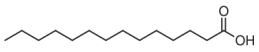
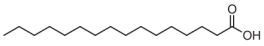
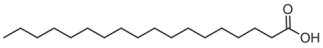
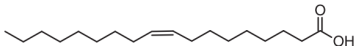
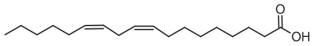
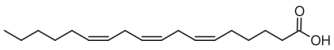
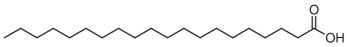


Figure 4 Example of price breakdown, forest to final customer, of nuts from Acre, Brazil to display the value distribution to local communities from the Nature Pays handbook by WWF (n.d.) based on data by Clay (2004). *Used with permission.*

2.4 Bio-based Oils and Fatty Acids in Personal Care Products

Due to an increasing demand for natural and or organic cosmetic ingredients, bio-based seed oils are more frequently used. Plant-based seed oils consist of a variety of saturated, mono-unsaturated, and polyunsaturated fatty acids that contribute to the function of cosmetics and personal care products (Vermaak et al., 2011). Some fatty acids common in cosmetics and personal care products are displayed below in Table 1.

Table 1 Fatty Acids common in cosmetics and personal care products.

Name	C:D	Chemical structure
Myristic acid	C14:0	
Palmitic acid	C16:0	
Stearic acid	C18:0	
Oleic acid	C18:1	
Linoleic acid	C18:2	
Linolenic acid	C18:3	
Arachidic acid	C20:0	

A commonly used fatty acid in cosmetics is linoleic acid as it moisturises the skin, aids the healing process of sunburns, and is used to treat Acne vulgaris (Vermaak et al., 2011). Compared to palmitic, oleic, and stearic acid, linoleic acid cannot be synthesised by the body and deficiency are shown through dry skin, cracked nails, hair loss, and increased trans-epidermal water loss. Both oleic acid and palmitic acid have been reported to have potent skin permeation enhancing effect. The fatty acids can similarly to the seed oil itself be used as ingredient in cosmetic and personal care products. The fatty acids can also be used as a component for e.g., emollients and emulsifiers.

3 Method

This master's thesis was based within the field of industrial ecology (IE), defined by White (1994) as "*the study of the flows of materials and energy in industrial and consumer activities, of the effects of these flows on the environment, and of the influences of economic, political, regulatory, and social factors on the flow, use, and transformation of resources"*. In this definition, there are core elements that nicely captures the main approaches of this study. The use of a systems perspective, the role of companies as well as forward looking practices were all fundamental elements for the outline of this study. To conduct a study within the IE field, several methods and tools are available to perform different kinds of assessments. The workflow, tools and methods adopted in this study are presented in the following sections.

3.1 Workflow

This master's thesis was conducted as a case study, applying an iterative approach and using both qualitative and quantitative methods. A case study is defined by Yin (2014) as "*an empirical inquiry that investigate a contemporary phenomenon in depth and within its real-world context, especially when the boundaries between the phenomenon and the context may me not be clearly evident*". In this study, sustainable sourcing of baobab and shea as feedstock for cosmetic ingredients was considered the phenomenon to be investigated. Data to understand both phenomenon and real-world context was collected through interviews and literature. Due to the Covid-19 pandemic, no visit to the geographical area relevant for the study was possible.

The workflow as well as the tools, methods, and the correlation to the research questions presented in figure 5 was inspired by PICABUE, a method for the development of indicators for sustainable development (Mitchell et al., 1995). In this study, the first three steps of the normally seven steps method (the "PIC" in PICABUE) were adopted to create a good basis for the identification of study areas and criteria. The tools and methods mentioned in the workflow is further described in section 3.2, Toolbox.

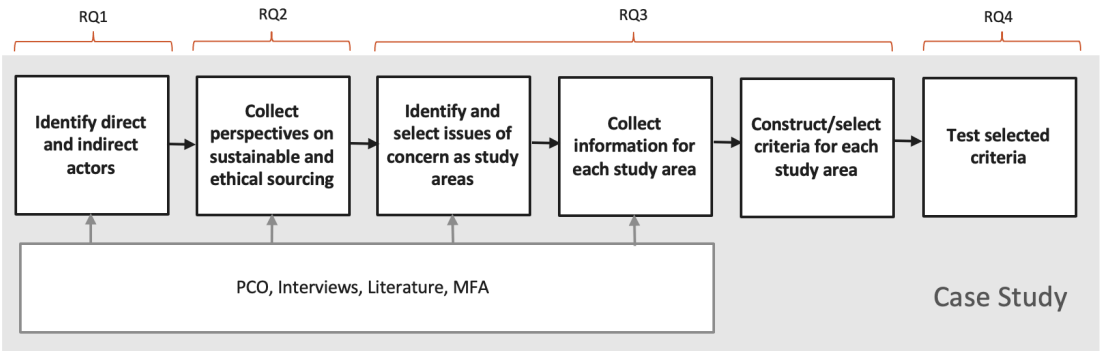


Figure 5 Workflow of this master's thesis connected to the research questions as well as tools and methods used.

The first step in the workflow was to identify the direct and indirect actors relevant for the sourcing. Here, the method product chain organisation (PCO) study was adopted. The PCO enabled a structured approach to understand and describe the actor network and technical process steps. The technical processes required for the product chain of producing a cosmetic ingredient was identified and visualised as a technical

flow model (TFM). The existing baobab pulp sourcing platform was used as a starting point for the TFM. The actors together with their roles and scope of action were thereafter identified. The TFM and the actor network together formed the PCO.

The second step, the collection of perspectives on what defines sustainable and ethical sourcing, was conducted through interviews. In each interview the following three questions were asked:

- What does sustainable sourcing mean to you?
- What does ethical sourcing mean to you?
- How would you describe your role in the product chain?

The first two questions were asked to identify the actor perspectives and key issues of concern related to sustainable and ethical sourcing. The third question was asked to describe each actor's scope of action. The perspectives gathered through the interviews were thereafter complemented with literature findings on different perspectives of sustainability.

As a third step, study areas were identified and selected in line with feasibility studies presented in section 2.2 and Appendix A. The basis for the study areas were a combination of issues of concern for sustainability mentioned in the interviews and study areas from conventional feasibility studies (e.g., TELOS as described in section 2.2). Some commonly mentioned issues within international standards and certifications were also included.

As a fourth step, detailed information was collected for each study area. Again, interviews and literature were the basis for data collection. In addition, a material flow analysis (MFA) was conducted to identify and quantify:

a) the volume of fatty acids and cosmetic oils produced by the current supply of baobab fruits based on the Aduna baobab sourcing platform
b) the volume of baobab fruits and trees required to supply an industrial demand of 50-100 tonnes of fatty acids or cosmetic oils

As the MFA required assumptions, a sensitivity analysis was conducted to assess the importance of each estimation and assumption.

The fifth step was to formulate criteria for each study area based on the information collected. The criteria were created with the purpose of synthesizing the large amount of information gathered and thus capture the essence of the study areas. Lastly, the criteria and study areas were used to qualitatively assess the sustainability and feasibility of sourcing baobab and shea as a raw material in the specific context of this case study.

It might appear as if the workflow was followed chronologically. However, the work and different steps were followed and completed in an iterative manner as interviews commonly led to new interviews in a typical snow-ball effect. For the specific case of combining a feasibility study with an in-depth sustainability study, it proved difficult to find the perfect method or tool. This motivates the somewhat unconventional approach of this study, with strong emphasis on understanding actors and their context rather than providing quantitative data as a basis for decision making.

3.1.1 The Roles of Baobab and Shea in this Study

The workflow presented in figure 5 is general and does not declare what is done for baobab and shea respectively. This section intends to complement the limitations in section 1.4 and clarify how baobab and shea are incorporated in the study. As the PCO is based on the existing baobab sourcing platform, it does not represent the conventional shea product chain organisation. However, the PCO is applicable for a specially sourced wild-harvested seed-oil used as raw material for cosmetic ingredient manufacturing. Actors involved in shea production and usage for cosmetic purposes have been included in interviews. Shea has also been a part of the literature search as it is a good reference to baobab in terms of commercialisation. The MFA is conducted for baobab only as this information for shea can be found through literature. The assessment framework is applicable to both species.

3.2 Toolbox

The tools and methods mentioned in section 3.1, Workflow, are described further in this section.

3.2.1 PCO

A product chain organisation study (PCO) is a management based method for studies of environmental management that can be used when analysing and improving an organisations' sustainability work (Baumann et al., 2015). There are two main steps in a PCO study. The first step is the definition and drawing of the technical flow model of the studied product in figure 6 presented as white boxes. The second step is the mapping of organisations and interactions along the TFM i.e., main actors, current and potential collaborations as well as power structures throughout the value chain. A product or material flow is always enabled by a set of actors, without these actors, no product flow. One of the benefits of using a PCO is the opportunity to identify the scope of action of each actor. The PCO framework is presented in figure 6.

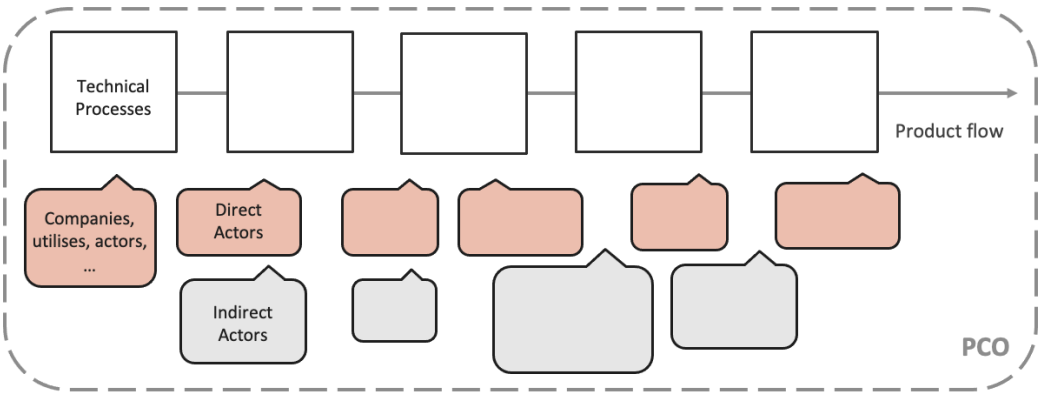


Figure 6 Product Chain Organisation method adopted for this study from (Baumann, 2012).

In this study, the existing sourcing platform of baobab pulp was the basis for the TFM. Each actor was identified as either direct or indirect actor. The direct actors were connected to any of the main technical process steps of the product flow. The indirect actors are connected to the product flow through their position in society or influence over a direct actor.

3.2.2 Interviews

Interviews can be used as a qualitative method to collect data from many different stakeholders (Bryman & Bell, 2011). The purpose of using interviews in this study was to collect both quantitative and qualitative data for the product chain organisation and to understand the perspectives of the involved stakeholders regarding sustainability and ethics related to sourcing. In this master's thesis, the interviews were conducted in a semi-structured manner i.e., with a mix of open and closed question with some flexibility to ask follow-up questions. The interviews were held digitally, and notes were taken during each interview. After each interview, the notes were summarised, and sent for approval by the interviewee.

The results from each interview were used for the mapping of actor interactions, understanding of the technical flow model as well as the various perspectives on ethical and sustainable sourcing. In addition to the semi-structured interviews, more informal continuous meetings with the key stakeholders were conducted throughout the study. All actors and individuals involved in the study are listed and described in Appendix C. The standard set of questions for all interviews can be found in Appendix D.

3.2.3 Literature Search

For the literature search, mainly Google scholar, Science Direct, and Chalmers Library were used to find relevant articles. The search words have been plenty due to the broad scope of this study. Some examples of search words are "nature's contribution to people", "land degradation Sahel" "baobab *(Adansonia digitata)",* "shea *(Vitellara Paradoxa)",* "West-African seed-oils", "non-timber forest product", "fatty acids baobab", and "fatty acids shea".

3.2.4 Material Flow Analysis

In general, a MFA is considered as suitable for the quantification of flows and stocks in the system as it tracks and quantifies a substance or a substance group as it moves through a system (Harper & Graedel, 2004). Bringezu and Moriguchi (2002) defines MFA as the analysis of throughput of process chains comprising e.g., extraction and harvest and is based on physical units, tonnes when quantifying the input and outputs of the processes in the chain.

In this study, the purpose of using the MFA methodology was to, in a structured way, quantify and visualise the processes including flows and stocks in the supply chains of the unconventional seed-oil baobab. Moreover, the MFA was conducted to indicate how much resources that would be required to fulfil the demand of cosmetic oil, and fatty acids.

3.2.5 Feasibility Study

As presented in Section 2.2, feasibility studies generally involve identification of critical questions for a set of study areas. The study areas differ depending on the project and the purpose of the study. To arrive at a definitive conclusion based on all aspects of a project, an assessment is conducted for each identified study area based on the information collected through critical questions. In this study, the relevant study areas were identified through the interviews with the actors in the product chain in combination with the conventional study areas presented in Appendix A.

3.2.6 PICABUE

The PICABUE method consists of seven steps to develop indicators for sustainable development (Mitchell et al., 1995). Indicators are commonly needed in sustainable development to synthesize masses of data, show a current position in relation to a desirable state, demonstrate progress, and/or to communicate status to encourage effective leadership. As mentioned in section 3.1, only the first three steps of the method were used for the purpose of constructing criteria. The first out of the seven steps are to get stakeholders to reach a consensus on principles and definitions of sustainability. The second step is to identify and select issues of concern e.g., no poverty, climate change, or circular consumption and production. The third step is to construct/select indicators of the issues of concern. These three steps (the PIC in the the PICABUE) inspired the identification of actor perspectives on sustainable sourcing, the collection of issues of concern, and the identification of criteria in this study.

4 Introducing the Case

In this chapter, the involved actors, the geographical boundary and relevant processes are described. General information about baobab and shea trees and their applicability in the cosmetic industry is also given.

4.1 The Local Context

In this master's thesis, the geographical areas of interest are Northern Ghana and South-central Burkina Faso, with Sudanian dry savanna as the main ecoregion as can be seen in figure 7 below (Beck et al., 2018). The Sudanian Savanna is a hot, dry, wooded savanna composed by large trees species and grassland (WWF, 2021). According to the United Nations Convention to Combat Desertification (UNCCD), land degradation is a problem in the region (UNCCD, 2019). Nkonya et al. (2016) highlight that land degradation have both direct and indirect impacts on human welfare as food, fibre and other terrestrial ecosystems goods originates from land. The degradation is accelerated by an exponential population growth and more severe climatic conditions. However, the UNCCD (2019) also mentions that there are sustainable land management (SLM) practices available that can protect fragile soil and improve land productivity. The rainfall in the region is highly seasonal with months-long dry season. WWF (2021) states that the main threats to biodiversity in the region are seasonal farming, grazing animals, and tree clearance for timber from agricultural and herding activities as well as wildfires.

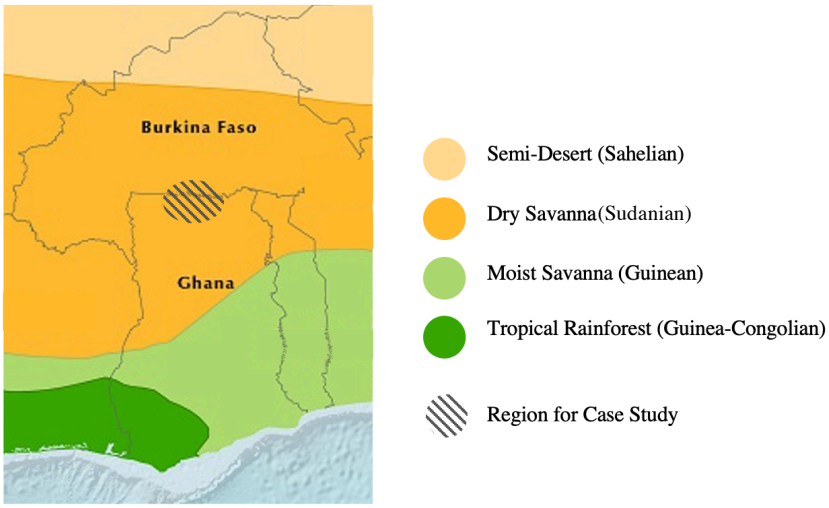


Figure 7 Ecoregions in relation to Ghana and Burkina Faso and the contextual area of the case study in this report.

The pan-African led initiative called "The Great Green Wall" (GGW) has a vision to create an 8000 km green wall through the Sahel spanning from Senegal to Djibouti. Even though Ghana is not officially a part of the Sahel as can be seen in figure 7, the Upper East Region from which the shea or baobab in this case study are collected have the same climatic conditions as the Centre-Sud region in Burkina Faso. Hence, the same type of challenges and opportunities as described for the Sahel are also relevant for Ghana. The GGW aims to restore 100 million hectares of currently degraded land, sequester 250 million tonnes of carbon, and create 10 million jobs in rural areas by 2030. Some measures to reach these targets and to restore the land of the Sahel are

investments in integrated ecosystem management, varied land use, and restoration of drylands and natural vegetation (UNCCD, 2021).

The state of the Climate in Africa report of 2019 presents that the climate in the region of interest will be characterized by warming temperatures and shifts in precipitation (World Meteorological Organization, 2020). Furthermore, climate change poses a high risk at impacting agricultural activities as projections indicate very concerning effects on food security and crop production. The Sahelian region is today associated with conflicts and human insecurity due to the climatic and humanitarian earlier crises in the region (UNCCD, 2019). Climate change increases tensions and competition for natural resources as both agriculture and livestock production are impacted. The UNCCD further highlights the negative image as a risk to the positive social and environmental development that can be realised through the available natural resources in the area.

Ghana and Burkina Faso are both parties to the Nagoya protocol. The party status of Burkina Faso entered into force on October 12th, 2014 and Ghana on November 6th, 2019 (Secretariat of the Convention on Biological Diversity, 2021b). According to the ABS Clearing House (ABSCH), Burkina Faso has established a national focal point (NFP), three different legislative, administrative or policy measures, and developed a national webpage. Burkina Faso has also issued a national interim report on the implementation of the Nagoya protocol. Ghana has currently only a NFP defined. The ABSCH is a platform for exchanging information on access and benefit-sharing for users and providers of genetic resources and/or traditional knowledge (Secretariat of the Convention on Biological Diversity, 2021a). According to the latest National CBD Action Plan for Ghana, the ratification and domestication of the Nagoya Protocol and ABS is included in the National Program Strategy (Ministry of Environment Science Technology and Innovation, 2016). The planned action is to develop and implement ABS guidelines and instrument as well as have relevant regulations enacted by 2017. The communicated goal was to have the legal instrument deposited and approved by December 2020. However, in 2021 there is not communicated through the ABSCH that the legal framework is up and running.

Finally, table 2 presents some general statistics to better understand the living conditions and long-term progress of development for the two countries, Ghana and Burkina Faso. The access to electricity is especially mentioned as it might affect further industrialization of domestic production. The Human Development Index (HDI) takes three basic dimensions of human development into account: a long and healthy life, access to knowledge, and a decent standard of living (United Nations, 2020).

Table 2 Country statistics for Ghana and Burkina Faso (The World Bank Group, 2021; United Nations, 2020).

Country statistics	**Ghana**	**Burkina Faso**
Access to electricity (% of population)	82% (2018)	14% (2018)
Access to electricity, urban (% of urban population)	94% (2018)	62% (2018)
Access to electricity, rural (% of rural population)	67% (2016)	5% (2016)
Total population in 2019	30,417,900	20,321,100
HDI 2020	0,611	0,452

4.2 The Indigenous Species, Where to Find Them and How They are Managed

Both baobab and shea are wild, indigenous species that can be classified as semi-domesticated. They are both common parkland trees that can be found in agroforestry parklands in sub-Saharan Africa (Boffa, 1999). The term parkland is defined by Boffa (1999) as "*landscapes in which mature trees occur scattered in cultivated or recently fallowed fields" and agroforestry parklands as "the occurrence of multipurpose trees on farmlands*". Meinhold and Darr (2020) has summarised that agroforestry systems can result in positive impacts such as additional income sources, access to nutritious food products, maintain biodiversity, reduce soil erosion as well as increase resilience towards climate shocks. In this section, both baobab and shea are introduced as well as their contributions to people. The information is gathered both from literature and from interviews with experts and local actors working with baobab and shea on a daily basis.

4.2.1 Baobab (*Adansonia Digitata*)

The ancient African indigenous baobab *(Adansonia Digitata)* tree is known for its majestic silhouette as seen in figure 8. The tree goes by many names such as "tree of life", and "upside-down tree", but the more common name baobab probably originate from the Arabic "bu hibab" which translates to "fruit with many seeds" (Islam-Faridi et al. 2020; Kamatou et al. 2011). The baobab is important to both humans and animals in arid and semi-arid parts of Africa as it provides several NTFPs, shelter and nutrition (Kamatou et al., 2011). These NTFPs include leaves, bark, fruits, and seeds that are important for livelihood and subsistence of many African populations (Buchmann et al., 2010). In fact, Buchmann et al. (2010) documented three hundred different traditional uses for the baobab products across three West-African countries. Moreover, the baobab holds a special traditional and cultural importance and is sometimes called "arbre a palarbe" from the tradition of men discussing and solving problems in the shade of the baobab tree.

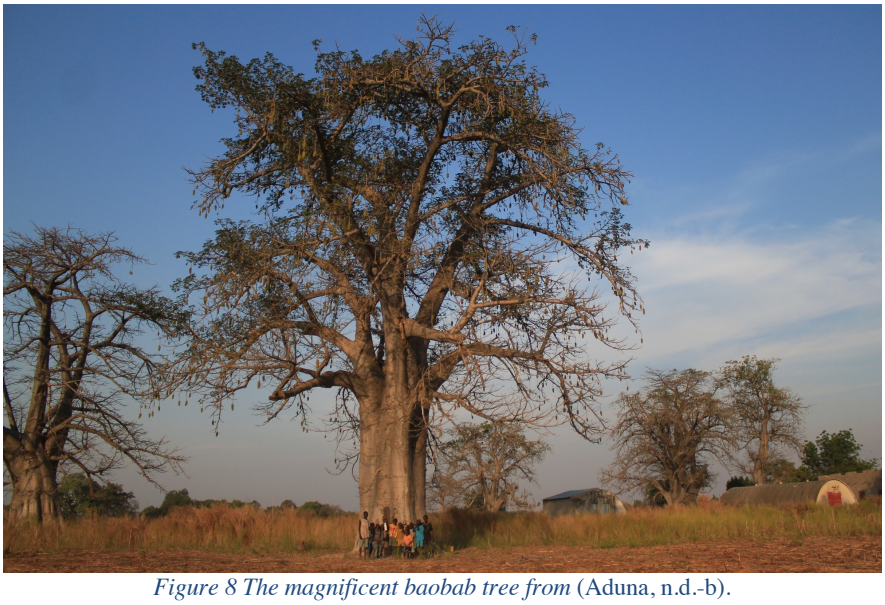


Figure 8 The magnificent baobab tree from (Aduna, n.d.-b).

According to research, it takes approximately 8-25 years before the baobab flowers and then produces seeds that can germinate (UNCTAD, 2005). However, according to several interviewees, it commonly takes several decades and even up to 100 years for

the baobab to flower (H. Pander, personal communication, March 23rd 2021; A. Hunt, personal communication, March 19th 2021). According to Wickens and Lowe (2008), a mature tree can produce more than 30 kg of fruit per year. However, according to baobab businesses, the annual yield is on average 120 kg per tree (N. Salter, personal communication, May 6th 2021). The incoherence between the findings from literature and from interviews displays the need to conduct a case study and further research.

The regeneration and conservation of the trees are often mentioned as a crucial aspect related to sourcing activities (J. Awaregya, personal communication, April 30th 2021; A. Hunt, personal communication, March 17th 2021). Lykke et al. (2021) even mention domestication of baobab in agroforestry or plantations as a potential action to ensure availability of seeds. Another aspect of regeneration is how the increased demand of seeds might interfere with natural propagation (J. Awaregya, personal communication, April 30th 2021; H. Pander, personal communication, March 23rd 2021).

During the last decade, both the European and the US market have gained interest in baobab pulp and seeds. The interest for the seeds comes mainly from the cosmetics industry as the baobab seed oil has an interesting fatty acid and vitamin profile for such applications (Komane et al., 2017). The baobab fruit, pulp and seeds are visualised in figure 9. Researchers such as Buchmann et al. (2010) have raised concern on how the increased commercialisation of the baobab pulp can pose a possible threat to local livelihoods in the form of reduced nutritional intake and changed power structures. Although, baobab seed-oils that are attractive to the cosmetic industry are not recommended for food. Meanwhile, other researchers such as Meinhold and Darr (2020) suggest increased commercialisation could be complementary and easily integrable in current livelihood strategies. In fact, the baobab fruit is under-utilised and sometimes left on the ground to rot in communities where a commercial value of the fruit does not exist (J. Awaregya, personal communication, April 30th 2021; N, Salter, personal communication, May 6th 2021).

Historically, baobab seed-oil has been used for medicine, food and cosmetics (Komane et al., 2017; Msalilwa et. al., 2020). Today, baobab seed-oil is mainly interesting for its potential application in moisturizing lotions, sun care product, and anti-aging creams as well as shampoos and conditioner (CBI, 2021a). Europe's aging population in combination with the millennials' interest in natural and organic cosmetics are listed as reasons for exporting baobab oil to Europe.

Figure 9 A collage of baobab fruit pictures. To the left, a baobab fruit hanging from a tree by Aduna (n.d.-a), in the middle an open fruit with pulp (Aduna, n.d.-c), and finally seeds adopted by Naliaka (2015) CC BY-SA 4.0.

The baobab oil is commonly reported as a yellow or golden coloured and odourless or slightly scented (Komane et al., 2017; Vermaak et al., 2011). The oil is stable with a reported shelf-life of two to five years (Vermaak et al., 2011). Komane et al. (2017) have reported the oil to be non-irritating, hydrating, moisturizing and occlusive in tests. The oil is reported to have high percentage of β-Sitosterol that is known to reduce DNA damage and free radicals. Moreover, vitamins A, D, E and F are present in baobab oil. While vitamin A and F are polyunsaturated fatty acids and known to rejuvenate and renew cell membranes, vitamin E is an antioxidant with anti-aging effects.

Table 3 presents the fatty acid profile of baobab oil from six different studies. The oil consists of a mix of saturated, monounsaturated, and polyunsaturated fatty acids. As can be seen in the table, the percentages differ with a quite substantial uncertainty. Lykke et al. (2021) have stressed the importance of closing the knowledge gap of indigenous seed-oils for similar reasons. The percentage of free fatty acids (FFA) i.e., the percentage of fatty acid chains not attached to glycerol to form a triglyceride range between 1.7 to 9.46 (Cissé et al., 2018; Msalilwa et al., 2020). Cissé et al. (2018) reported different amount of FFA depending on oil extraction methods. In addition to these fatty acids, several studies present findings of 3-10% of cyclopropenoid fatty acids (CPFA) (Msalilwa et al., 2020; Sidibe & Williams, 2002). CPFA may be harmful if consumed in quantity and are potentially carcinogenic. According to Msalilwa et al. (2020), the most frequently reported CPFA in baobab oil are sterulic acid and malvalic acid. Due to the presence of cyclopropenoid fatty acids (CPFA), neither World Health Organisation (WHO) nor the Food and Agriculture Organization (FAO) recommend baobab oil as an edible oil.

Table 3 Fatty Acid composition of Baobab (Adansonia Digitata) from six different studies.

Reference		**Diop et al. (2006)**	**Komane et al. (2017)**	**Vermaak et al. (2011)**	**Msalilwa et al. (2020)**	**Lykke et al. (2021)**
Country of origin		Burkina Faso	South Africa	-	Tanzania	West Africa
Fatty acid		% of total fatty acids	% of total fatty acids	% of total fatty acids	% of total fatty acids	% of total fatty acids
Myristic acid	C14:0	-	0.1	0.78	0.28-0.34	0.1
Palmitic acid	C16:0	27.8	28.5	18-30	14.99-20.48	23.1
Palmitoleic acid	C16:1	0.34	0.25	-	0.78-0.99	0.2
Stearic acid	C18:0	3.1	5.85	2.0-9.0	1.34-2.16	4.2
Oleic acid	C18:1	41.6	28.46	30.0-42.0	23.60-27.67	35.6
Linoleic acid	C18:2	27.0	35.93	20.0-35.0	12.16-26.14	32.2
Linolenic acid	C18:3	0.31	0.5	1.0-3.0	3.64-5.48	1.3
Arachidic acid	C20:0	-	0.7	-	0.54-1.3	0.6

4.2.2 Shea (*Vitellaria Paradoxa*)

For the past 3000 years, the shea tree has been one of the most economically and culturally important indigenous species in Sudanian agroforestry systems (Seghieri, 2019). In figure 10 below, shea trees are seen integrated in a farmland. Today, the shea value chain is an important mean for income generation to women in rural areas (Bup et al, 2014). FAO in collaboration with Global Shea Alliance (GSA) predicts that an expansion of the of shea parklands and increased collection productivity can almost double the gross income for women collectors (Bockel et al, 2020).

Figure 10 Shea trees and farmland in Northern Ghana (Fassio & CIFOR, 2017a) CC BY-NC-ND 2.0.

In West-African countries, shea contributes with income generation and food security. Boffa (2015) has summarised the local use of different shea products such as fruit pulp, kernels, butter, secondary products, and wood. The shea fruit and dry kernels are visualised in figure 11. The fruit pulp is widely used as nutritional resource due to its content of ascorbic acid, iron, calcium, and vitamins A and B. The oil extracted from the shea kernels is widely used as cooking oil. In addition to its edible applications, the shea butter is used for hair moisturizer, soap ingredient, wood and leather treatment, treatment of skin problems. Boffa (2015) further highlights the use of shea for medicinal applications e.g., for the relief of rheumatic and joint pains, quicken healing times and prevent infection of open wounds. Wood, bark, husk, and kernel cake also have a local value as charcoal, furniture material, and fuel.

Figure 11 A collage of shea fruit. To the left, shea fruit hanging from a tree by Tiveau and CIFOR (2006) CC BY-NC-ND 2.0 and shea kernels. To the right, dry kernels by Fassio and CIFOR (2017b) CC BY-NC-ND 2.0.

In 2019, both Ghana and Burkina Faso were represented in the top four shea producing countries in Africa (FAO, 2021). Ghana is reportedly the largest producer of unrefined shea butter (CBI, 2021b). Lykke et al. (2021) also states that shea can be seen as a success story for the commercialization of indigenous seed-oils. The number of shea trees available in the country are around 94 million which can generate around 60,000 tonnes of shea nuts produced annually. The annual production of shea kernels in Ghana over the last decades is presented in figure 12.

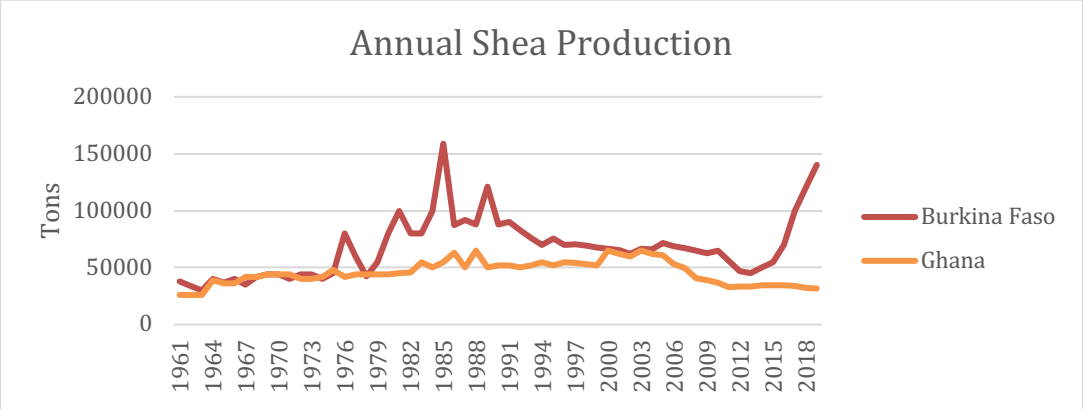


Figure 12 Annual production of Shea in Ghana and Burkina Faso based on data from FAO (2021).

The global shea butter market is expected to reach a value of USD 2.9 billion by 2025 and the current export value of shea butter from Ghana alone is estimated to USD 66 million (CBI, 2021b). The Global Shea Alliance (2021) report that out of the shea not being kept locally for traditional uses, 90% of collected shea kernels are purchased by traders for further processing. From this fraction, 50% is processed within the African continent and the other half internationally. GSA further report that out of the shea products exported, 90% is used by the food industry while the remaining 10% is used in cosmetics or personal care products. Internationally, shea is used as an edible ingredient and an important substitute for cacao butter. The presence of stearin and olein in shea butter makes it suitable as raw material in soap, cosmetics, detergents, candles, cooking oil and margarine (Iddrisu et al., 2019). Currently, the traditional shea butter extraction method is the most common. However, mechanical extraction, enzymatic extraction and chemical (solvent) extraction are also potential shea butter production methods.

4.2.3 The Indigenous Trees' Contributions to People

Wild trees contribute to people through regulation of environmental processes, materials, and non-material values. Both baobab and shea contribute to the habitat creation and maintenance of gallery forests that are biodiversity hotspots within the Sudanian savannah parklands (Lykke et al., 2021). Moreover, baboons, elephants, and chimpanzees have been found to feed on baobab and thus the trees regulate their habitat (Wickens & Lowe, 2008). However, baobabs can also be a home to bollworms that are a cotton pest which negatively contribute to people who rely on cotton production for their livelihoods. All plant species, including shea and baobab sequester carbon and thus contribute to climate change mitigation. Bockel et al (2020) have found that shea kernels have a negative carbon footprint of 1.04 tonnes of CO_2 per ton produced. Generally, trees contribute to surface water balance through evapotranspiration. Shea is also commonly found in agroforestry parklands, the dominant farming system in the relevant area. Studies suggest that properly managed agroforestry system could recycle up to 30–45% of rainfall by vegetation transpiration (Seghieri, 2019). Thus, the trees contribute to the regulation of freshwater quantity, location, and timing. Moreover, baobab trees can be used as water storage for local communities. By hollowing the trunk, with apparently no harm to the trees, 1800-9000 litres of water can be stored for the dry season depending on the size of the tree (Wickens & Lowe, 2008).

Shea litterfall has been found to improve soil fertility by increasing organic matter, total and available nitrogen, total and available potassium, and total and available

phosphorus (Seghieri, 2019). Both baobab and shea have been shown to increase productivity as increased soil fertility around the trees, can enhance crop production (Sanou et al., 2012; Seghieri, 2019). The trees can be seen to have abilities that absorb and buffer hazards as the tree canopy creates a microclimate that significantly buffers temperature variation expected from climate change. In addition, the fire proof trunk of baobab can help reduce the effects of wildfires (Wickens & Lowe, 2008).

In addition to the regulating contributions both baobab and shea can supply, they also contribute with materials and assistance as mentioned in earlier sections on baobab and shea. Baobab pulp, leaves, bark, and seeds have for example been used in traditional medicine to treat everything from diarrhoea, constipation, and fever to intestinal inflammations and wounds (Wickens & Lowe, 2008). Shea on the other hand is the second most important vegetable fat for cooking used in Africa and has a long tradition of cosmetic utilisation (Seghieri, 2019). For non-material contributions, baobab as the "arbre a palabre" is important in for learning and inspiration. Both baobab and shea are important in ceremonial activities (Seghieri, 2019; Wickens & Lowe, 2008). In the region of interest, the emergence of baobab trees is commonly seen as loved ones that has passed away and that come back to visit (J. Awaregya, personal communication, April 30th 2021). In addition, the baobab seeds have an important function within the local funeral ceremonies.

4.2.4 Land Tenure

When talking about wild grown species it is impossible not to mention the topic of land tenure. The land law system of Ghana is complex (Sarpong, 2006). Most commonly, the land is managed through traditional laws, where skins/stools i.e., chieftaincies or representatives for tribal systems distribute land to families within the villages and communities. Although, public and constitutional laws that regulate land exist too. However, it is estimated that 80% of land is manged through the customary land tenure including the skins/stools system.

The traditional distribution of land in Burkina Faso is according to Poole et al. (2016) through ethnicity. At community level it's the village chief or clan head that determines how land is distributed among the people in the community. Within each family, the family head then distributes the rights to his wives and sons. However, in addition to these traditional procedures, there is also a legislative framework adopted in the 1990s.

To better understand the local structures, the director of the local NGO was consulted on the matter of land tenure. Traditionally, in the region where ORGIIS operates, "tendanas" are the eldest inhabitant of a local community (J. Awaregya, personal communication, May 10th, 2021). The tendanas distributes the available land to the inhabitants in the community.

4.3 Actors

In this section, the initiating actors to this project are covered. All actors are briefly described as well as their motivation and reason to work with indigenous species like shea and baobab.

4.3.1 Global B2B Specialty Chemical Company

Evonik Industries AG is a German, world leading specialty chemical company, operating in several different markets. Evonik is divided into five different business divisions. The business division Nutrition & Care is divided into three business lines of which one is Care Solutions that offers among many other products, emulsifiers and cleaning ingredients for the cosmetics industry. To produce many of these cosmetic ingredients, fatty acids are needed.

The increasing demand of natural and sustainable cosmetics and personal care products is a driving force for Evonik Industries AG to investigate new sustainable bio-based raw materials. In addition, for the cosmetic industry in general, it is important to consider competition with local food supply when sourcing bio-based raw materials. Evonik wants to "Lead Beyond Chemistry" and thus wants to walk the extra mile for e.g., sustainability. Evonik has identified the Great Green wall initiative as an opportunity to combine commercial activities with socio-ecological engagement. Sustainably sourced fatty acids and/or cosmetic oils based on shea and baobab are in line with this ambition. However, the sourcing scheme of this case study is new to Evonik as the common practice is to have a multitude of suppliers that provide the same resource. Meanwhile, the sourcing of baobab in particular would primarily involve a single supplier for the same product: the partnership between the UK SME Aduna and their Ghanaian NGO Partner ORGIIS.

4.3.2 Small Medium Enterprise (SME)

Aduna Ltd. is a United Kingdom based social business and health food brand. The company sells a range of African sourced superfood powders and teas based on ingredients such as baobab, moringa, and fonio, both in bulk to private actors and in consumer packaging to consumer markets. The core of the company is the baobab fruit; the indigenous African fruit that connected the two founders Nick Salter and Andrew Hunt. Today, approximately 1800 women are involved in the harvesting and processing of baobab in Ghana and Burkina Faso through Aduna's partnership with ORGIIS.

Over the past 10 years Aduna has pioneered the introduction of baobab into Western markets, including an extensive and innovative campaign to "Make Baobab Famous". They have completed several investment rounds and are one of the few private companies involved in the Great Green Wall Initiative. The two co-founders Andrew Hunt and Nick Salter believe in the "Trade not Aid" model, meaning that rural and cash-poor communities can become involved in a market, which increase both their independence and their income. Based on this idea, Aduna has had discussions with the UNCCD to initiate the Great Green Wall Sourcing Challenge (GGWSC) to challenge large corporations to source raw material from the Sahel. Aduna is also actively involved in working with the World Economic Forum to support the Trillion Trees Challenge.

4.3.3 Local NGO

ORGIIS is a local NGO operating in the Upper East region of Ghana and Centre Sud region of Burkina Faso with their head office in Paga, Ghana. ORGIIS aims to reduce poverty through sustainable utilisation of local resources. Their vision is sustainable communities driven by indigenous development with the mission to empower communities using local knowledge. One of their strategic goals for 2023 is to increase

income through the promotion of viable agricultural and NTFPs value chains. Another strategic goal is to promote responsible use of natural resources through climate change adaptation, conservation and environmental protection. In the partnership with Aduna, ORGIIS manages the operational work in Ghana, including price negotiations for the raw material and transport and all communication with collectors and cooperatives.

4.4 The Baobab Pulp Sourcing Platform

To supply the "superfood" baobab fruit pulp for an international market, Aduna and ORGIIS are currently operating a sourcing platform for baobab. The core of this already operational sourcing platform for baobab pulp is the close partnership, where the local NGO manages the local operations and supply while the SME manages the demand side of the business.

The process steps and related material flows of this sourcing platform are visualised in figure 13. Each year, approximately 1000 tonnes of baobab fruits are collected from the wild trees by the women cooperatives currently integrated in the sourcing platform. These fruits are sent to a fruit processing facility in Paga, Ghana after a temporary storage time in local communities. Within the processing facility, the fuzz on the baobab is removed, the pod is cracked open, and the pulp and seeds are taken out. Thereafter, pulp is separated from the seeds, pounded, sieved and packed into bags for shipping.

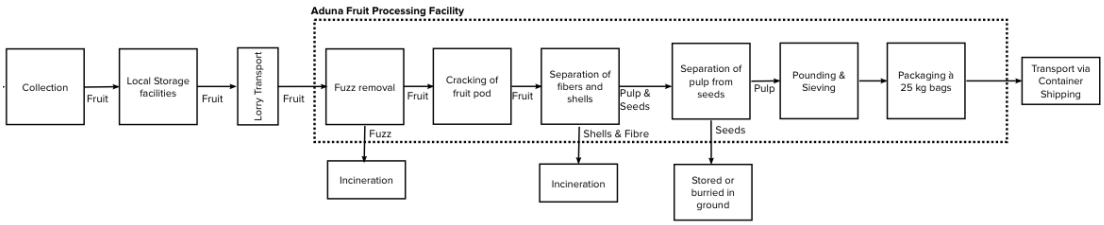


Figure 13 Existing sourcing platform for baobab pulp powder.

As can be seen in figure 13, the baobab pulp is the only part of the baobab that generates monetary value by being sold on a market. However, also the seeds, fibre, and shell have potential value that are not captured by the current supply chain. The husk and fibre are currently incinerated, and the ash is sometime used to enrich soils. The seeds generated from the fruit are not used for any commercial purpose and are currently stored to potentially be used in the future. If not stored, the seeds are buried in the ground or given to animals in local communities as feed. A small fraction of the seeds is used for local traditional ceremonies and regeneration.

The local NGO operates according to a process called "cooperative union model" which includes creation of cooperative unions, group dynamics, and local capacity building. The first step of the cooperative union model is to organise fruit collectors into groups that later become small cooperatives and unions. When a new group is well functioning and have clear leadership, the capacity building can proceed. ORGIIS evaluate what quality and quantities the group can deliver. Thereafter, they are integrated to the supply chain. In addition to supporting the formation of stronger cooperatives and unions, the NGO also conduct NTFP's quality training as well as business management training to strengthen local entrepreneurial skills. The capacity building is a process that can up to two years.

The price for the baobab fruit that Aduna pays is higher than the market price. The price is negotiated with the tendanas or village chiefs for each community. The basis for this price is primarily the value of the baobab pulp. When a price (X in figure 14) is agreed upon, two contracts are conducted, one between ORGIIS and the collector cooperative and one between ORGIIS and Aduna. By being the coordinating actor, the NGO can balance the supply and demand. Basically, they can make sure that the expectations regarding volume, quality, and delivery time are managed.

The payment for the baobab fruit is divided into an individual payment and a collective payment as represented in figure 14. The individual payment is 86% of the negotiated price of a baobab fruit (X) and is paid directly to the individual women collector. The collective payment of 14% goes to the cooperatives when they have collected 100 bags of baobab fruit. This sum acts as a safety net for the community members, who can call upon it in the case of household emergencies. There is also an organic premium of 10% of the full price of the baobab fruit, which is commonly paid on completion of the processing season during a ceremony and celebration. In addition to the purchase price above, Aduna has initiated a community impact fund that originates from 10% of the total fruit purchasing budget for the season (Y in figure 14). This is managed and disbursed by ORGIIS and allocated towards needful community projects related to the baobab value chain, e.g., community owned storage units, tricycles and tree planting activities. Any of the communities can apply for the fund, with ORGIIS evaluating and making a final decision.

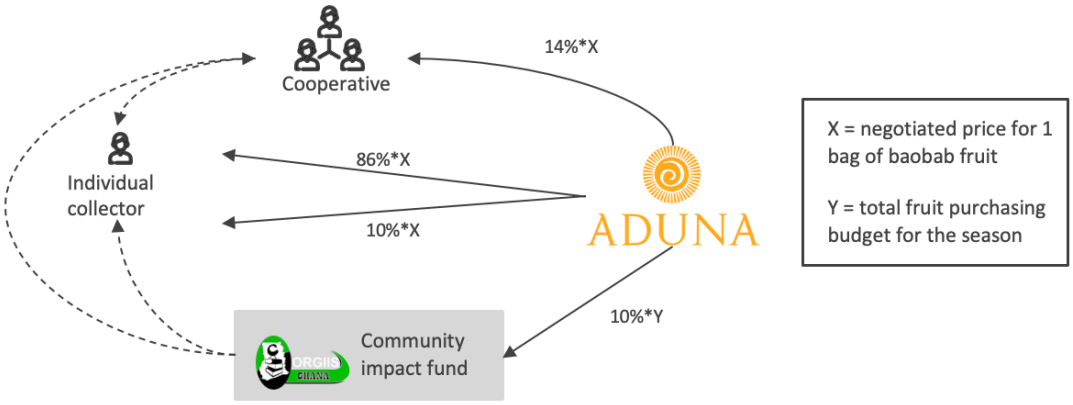


Figure 14 Monetary value flows within to the Aduna current baobab sourcing model.

4.5 What Can we Learn from the Case Study?

An existing sourcing platform for baobab pulp exist that is described as ethical and sustainable by its enabling actors. Baobab seeds show interesting properties as a cosmetic ingredient and are currently an under-utilized by-product from the baobab pulp production. In addition, baobab seed-oil is not suitable for consumption which is of particular interest to the cosmetic industry. Shea is already a commercialized indigenous product that is used in the cosmetic industry. An increased market demand and extended local processing of shea and baobab has the potential to improve local livelihoods, conserve the indigenous trees and thus their many contributions to people. This can be put in a broader context by mapping the product chain organisation of a personal care product based on the presented baobab sourcing platform.

5 The Product Chain Organisation

The foundation of the PCO is the current sourcing platform presented in the Chapter 4, but with additional process steps relevant for the production of a bio-based cosmetic ingredient. In synergy with the PCO method presented in Chapter 3, the technical processes are first described followed by a description of the actors enabling the product flow. Each actor's role and scope of action are presented flowed by a summary and analysis of the PCO. A summary and an analysis of the PCO concludes this chapter.

5.1 Technical Flow Model

The technical flow model (TFM) is constructed by a combination of technical processes needed to produce a bio-based cosmetic ingredient. Figure 15 presents these main technical process steps when a wild harvest NTFP's is used as raw material. The current baobab pulp sourcing platform represents the two first process steps in the TFM. The oil processing is assumed to be conducted within Ghana while the two last process steps are assumed to be conducted outside of the African continent. The cosmetic ingredient manufacturing in done by the global B2B speciality company presented in section 4.3.1. These process steps are applicable to both baobab and shea. However, the detailed practices within the fruit processing and the oil processing steps vary depending on the raw material.

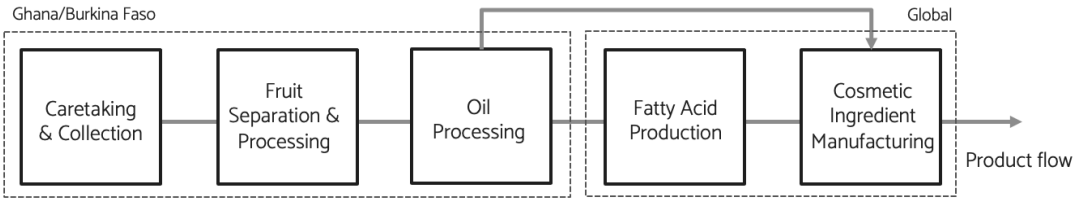


Figure 15 Technical flow model representing the main process steps.

5.1.1 Caretaking and Harvest

As described in chapter 4, both shea and baobab are defined as semi-domesticated species, meaning that they are not cultivated as other oil species such as palm. The long time required for shea and baobab to mature and start bearing fruit, makes caretaking especially important. Some even argue that baobab could be considered as a finite resource due to their long regeneration time (N. Salter, personal communication, May 6th 2021).

Both shea and baobab fruits are commonly collected by women from the local communities and collector cooperatives. The word collected instead of harvest is used as the fruits are mostly picked form the ground when they have fallen from the tree. For baobab collection, tools can be used to make the dry baobab fruit pod fall down from the tree. This can avoid tree climbing to fetch the pods while still on the trees. The shea is most commonly collected from the ground as they fall down when they are ripe. Table 4 represent the annual calendar for baobab and shea related activities. The annual calendars of baobab and shea do not overlap but are spread out over the year.

A crucial difference between shea and baobab is how the kernels/seeds are currently used. Baobab seeds can be considered as a by-product while the shea kernels drive the

fruit collection. In addition, shea kernels are used as an edible table oil while baobab seed-oil is unsuitable for consumption.

Table 4 Annual calendar of baobab and shea products according to (Poole et al., 2016) and own modifications.

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Baobab	*Fruit*	*Fruit*	*Fruit*		*Leaves*	*Leaves*						*Fruit*
Shea					*Fruit*	*Fruit*	*Fruit*	*Fruit*	*Fruit*	*Fruit*		

5.1.2 Fruit Separation and Processing

In the case of baobab, the fruit processing and separation are conducted at the SME/local NGO facility in Paga, Ghana. The details of this process have already been covered in section 4.4. The baobab fruit pulp has to be processed before the start of the rain season. When the seeds are separated from the pulp they can, if stored correctly, be saved for several years before they deteriorate.

For shea, de-pulping i.e. the separation of pulp from the shea kernel is traditionally done by the women cooperatives that collect the shea fruit (Iddrisu et al., 2019). To store shea fruits before de-pulping can negatively impact quality and quantity of the shea butter. The shea fruits must be taken care of within three days before the fruit and kernel quality is lost. Therefore, the shea fruit processing and separation of kernel occur continuously over the shea season. After de-pulping, the kernels are either sold, stored, or processed into shea butter by the cooperatives. As mentioned before, shea is not integrated in the SME product portfolio and operations but rather function as a benchmark to baobab.

5.1.3 Oil Processing

The current available methods for oil and butter processing are described in this section. Options to these methods that can enable higher scale of oil production and/or different benefits are also presented. For baobab and shea, the existing oil processing methods are described in table 6 below and in further detail in Appendix E.

Currently, cold pressing is the most suitable processing technique for baobab seeds. Even though, the oil yield is considerably low compared to the yield that can be generated from solvent extraction. However, if the oil processing step is to be carried out locally in Ghana or Burkina Faso, cold pressing is currently the only viable option. The only existing cold pressing facility available in Ghana for commercial scale production is located in Kumasi. Therefore, seeds need to be packed into bags in Paga and transported the 600 km distance to Kumasi.

The advantages of using cold pressing include the preservation of the physicochemical properties, relatively inexpensive after the initial capital cost and no environmental concerns related to the operation. The disadvantages include the low yield, yellow colour (which is negative for application in cosmetics) and dependence on pre-treatment of seeds/kernels.

For shea, the traditional oil extraction method is mainly used when processing kernels. In fact, around 80% or the Ghanaian shea butter is processed through the traditional method. Advantages associated with this process technology is that the traditional knowledge of women can be used and encouraged. However, the yield is generally

lower compared to other extraction methods. Furthermore, the process requires both water and firewood and is quite uncontrolled which can affect the quality of the butter.

Table 5 Oil processing methods for baobab and shea.

Baobab Methods	**Key characteristics**	**Oil Yield [%]**
Cold Pressing	Mechanical pressing most common method for continuous treatment of oleaginous seeds. Industrial pressing of oilseeds is realised using continuous screw presses	6.3–15%
Solvent extraction with n-hexane	A solvent (n-hexane) added to pulverized seeds to enable the oil and fatty constituents to dissolve from seeds	30%
Shea Methods	**Key characteristics**	**Oil Yield [%]**
Traditional	Traditional production method used to produce about 80% of Ghanaian shea butter	25–40%
Traditional - IMC	Improved traditional method tested in Gbimsi in northern Ghana	67%
Mechanical Cold Pressing	Mechanical method using pressure to extract the oil from kernels or seeds	30–45%
Solvent extraction with n-hexane	A solvent (n-hexane) added to pulverized kernel enable the oil and fatty constituents to dissolve from kernel	40–66%
Enzyme extraction	Enzyme extraction uses water-soluble enzymes to degrade the cell walls of release oil from kernel/seed	47–74%

As presented in table 5, the alternative oil extraction methods for shea range from improvements of the traditional method to purely industrial methods such as solvent extraction. The full range of advantages and disadvantages of the various alternative methods can be found in Appendix E. Recent studies conducted by Didia et al. (2018) highlights enzyme extraction as the way forward for shea butter processing in Ghana. They mention increased yield, high quality oil and quality of the residual meal as some of the advantages. The main disadvantage highlighted for this novel method is the cost of importing enzymes to Ghana.

The high oil yield for shea presented in table 5 might explain why shea butter is more attractive and successful on commercial scale. Even though the properties of baobab seeds are different to shea kernels, baobab processing can perhaps learn from shea to increase yield and quality of the final seed-oil.

5.1.4 Fatty Acid Production

Fatty acid production through hydrolysis, followed by distillation is a common process that has been used on industrial scale for almost a century. Shea based fatty acids are already on the market and are sold at commercial scale. The main challenge for baobab is to find a producer that can work with relatively small quantities such as 25-100 tonnes of oil per year.

5.1.5 Cosmetic Ingredient Production

As explained in section 1.4, the detailed processes within the cosmetic ingredient manufacturing are not of focus in this study. Therefore, the technicalities of cosmetic ingredient manufacturing are not further explained in detail. However, the perspectives and roles of the actors behind this process steps will be included to enable understand the dynamics of the full product chain.

5.2 The Enablers of the Product Flow

In figure 18, the TFM is populated by direct and indirect actors. The direct actors are represented by orange boxes and are involved directly in one or several of the process steps. The indirect actors are represented in the grey boxes below the brackets. The brackets indicate where the indirect actors influence the direct actors and thereby the product chain.

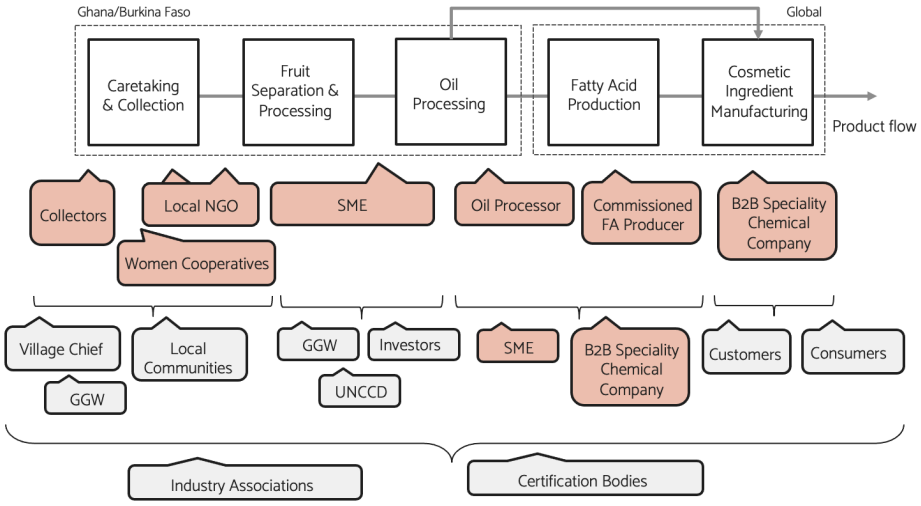


Figure 16 The product chain organisation of a wild harvest raw material used as feedstock for cosmetic ingredient.

Each actor identified in figure 16 have a specific role and scope of action. For example, the actor Evonik has the role as a B2B cosmetic ingredient producer. They define their scope of action to engage in strategic projects, enable customers to make more sustainable choices, and to support local community development. For further description of roles and scope of action for the remaining actors, see table 8. From the roles and scope of actions identified in table 8, some key areas important for the realisation of the product chain are identified. These are described, one by one, in the following sections.

5.2.1 Local Capacity Building

The development of local communities is highlighted by most actors in table 8. By the actors closer to the location of raw material, this is framed as "capacity building". The B2B manufacturer, talk about themselves as supporter of local development and by that not only financial development. The industry organisation also mentions the empowerment of women and capacity building as their scope of action in the product chain. The local NGO can clearly describe what it means with local capacity building since they have established a clearly defined process for many years as described in section 4.4.

The international organisation UNCCD also describes itself as supporter of local capacity building. Trade is highlighted as a potential barrier to more extensive export of indigenous products such as baobab. The barriers to trade are both technical and tariff related. Commonly, the tariff is low for unprocessed raw materials, but the tariff escalates when the raw material is further processed. In addition to tariffs, the technical barriers to trade are also important to highlight. They include the quality requirements

that are needed to export a commodity to e.g., Europe. The local NGO also mentions quality requirements as a barrier when selling and exporting indigenous products.

Table 6. Actor roles and scope of action in the PCO.

Actor Roles & Scope of Action			
Role	Local NGO	SME	Global Cosmetic Ingredient Manufacturer B2B
Scope of action for direct actors	• Capacity building • Find market opportunities for local resources • Bridge market and local communities • Promote and advocate for policy to conserve natural resources and to regenerate the natural environment • Regeneration of trees through plantations	• Create a market demand for West-African indigenous products • Advocate and spread new business model – market demand creation • Challenge the current investment model • Support local capacity building • Initiate strategic and ethical partnerships • Regeneration of trees through partnership with the GGW	• Support local development • Communicate and interact with customers • Support scalability of activities • Guarantee fair pricing • Active supporter of other actors in product chain • Provider of demands and requirements • Initiate strategic projects and supplier development • Enable consumers to make more sustainable choices
Role	• International Organisation	• Industry Associations	• Global Cosmetics Manufacturer B2C
Scope of action of indirect actors	• Address issues and potential conflicts regarding land use within and between nations • Act as facilitator and coordinator of activities • Resource mobilisation • Support funding and technical capacity building • Partner and support the GGW	• Represent all shea value chain stakeholders from small scale collectors to large scale industrial partners • Member driven and the current focus is promotion of shea, its sustainability, quality, and the empowerment of women as well as conservation of parklands • Promote shea by finding new uses and markets through research, conferences, and policy advocacy	• Work together with suppliers instead of backing out from risk areas • Be transparent towards customers • Engage in external partnerships • Enable consumers to make more sustainable choices

5.2.2 Policy and Legislative Support

The strong need for regulative and policy measures to protect the indigenous species like baobab and shea growing in the area was mentioned by the local NGO. Currently there is no regulative measure to protect these species compared to planted crops such as palm, cacao, and coffee. Without legislative measures in place to protect the trees, it is important to bring value to the trees in other ways to protect them from being cut down in favour of cash crops. The industry association GSA also highlighted that one aspect of their role is to provide policy advocacy. One threat to the baobab trees mentioned by the SME is the picking of leaves. In Burkina Faso a law has been established to forbid the picking of leaves from the baobab tree. However, this is not done so far in Ghana which have resulted in leave pickers coming to Ghana instead. This indicates that the local actors have identified the need of stronger policy to protect their local resources.

5.2.3 Market Demand Creation

The actors operating in Ghana describes themselves as the bridge between the collectors and the buyers. The local NGO has an important role as this bridge to negotiate price, quality requirements as well as time and quantity of supply. The close partnership between the SME Aduna and local NGO ORGIIS is one example of how a bridge is created between the available indigenous products to a demand outside of Africa for nutritious "superfoods".

The SME could very clearly describe their role in the product chain. They have identified a large supply and underutilized resource in several of the West African indigenous products, baobab being just one example. To start the process of creating a market for these products, the first step is to take on the role to challenge investors and their current investment models. The current model used by investors builds upon monopolising and controlling an idea or business model. However, in the case of Aduna and the underutilized market and supply of indigenous products the opposite is needed. Aduna argues that investors should look at the impact of the idea and the actual sustainability of this impact. Aduna does not fear replication of their business model. Instead, they want to others to replicate it since that might expand the market for indigenous products and match the existing non-utilized supply.

5.2.4 Collaboration and Partnerships

Collaboration and formation of strategic partnerships is a topic mentioned in all interviews. The local NGO mentions partnerships in the sense of finding a market for the indigenous products available in the region. The global B2B company mentions partnership and collaboration with customers, suppliers and local communities. One question posed by the B2B is "how can we support?". Currently, the global company is not completely sure on how they can engage in a way that is benefiting the local community in a positive manner. This is also in line with difficulties of assessing social sustainability as mentioned in section 2.1. In this study, we can see that most actors want to include social sustainability in their scope of action. Therefore, it is important for them to assess and take relevant action for these aspects.

From talking to the global actors, it is clear that they have a lot of influence over the product chain and thus also the related environment and communities. However, they are in turn influenced by the consumers and their preferences. As mentioned in section 1.1, the current market trend is for consumers to look for natural, and more sustainable options for their beauty and personal care products. This puts pressure on the cosmetic producers and their suppliers to enable these kinds of options. With a growing global population on earth, to not compete with edible alternatives for cosmetics is also something to consider.

Alongside creating demand, the SME must also consider consumer preferences and consumer trends in continuing to keep baobab relevant and to not be perceived as a fad or momentary trend. Demand has to be not only scalable but consistent over long time horizons. Potential investors can also be put off by the market creating business model that Aduna has pioneered.

5.2.5 Regeneration and Conservation

To contribute to the regeneration and conservation of the wild trees is mentioned as a key aspect of their role by the local NGO, the industry association, and the SME as well as by the UNCCD. However, the included activities and engagements vary. The role of the UNCCD in regeneration and conservation primarily lies in its role as a key supporter of the Great Green Wall (GGW) initiative. The role of the UNCCD within the GGW is to facilitate and coordinate the parties and the private sector. Furthermore, the UNCCD's role is to track investment, provide technical support, mobilise resources for the GGW parties, and engage in advocacy.

The SME Aduna has applied for funding through the GGW to plant trees and seedlings and thus contribute to regeneration. This was done in collaboration with the local NGO ORGIIS and the local communities through a scheme where women collectors got to take care of baobab seedlings. Nowadays, ORGIIS engages in regeneration from own funding and could use more support from private companies and investors to plant more trees.

In addition to regeneration, both Aduna and ORGIIS mentioned conservation as an aspect of their role in the product chain. By creating a market that adds monetary value to the baobab tree, an economic incentive is generated for the local communities to conserve and safeguard and renew their baobab populations. Several researchers have claimed similar interconnectedness between increased value and conservation for both baobab and other indigenous species (Kamatou et al., 2011; Lykke et al., 2021; Vermaak et al., 2011). Similarly, the shea industry association GSA mentioned that they always try to find new uses and markets for shea. Furthermore, they mentioned the protection of shea resources i.e., parklands as a key sustainability aspect for GSA and their members. How GSA actively works with planting trees is unclear from the findings of this study but engagement through research, conferences, and policy advocacy were mentioned by the managing director.

5.3 Material Flow Analysis

Baobab seeds are under-utilized with potential for commercialisation and application in the cosmetic industry. Therefore, understanding the raw material requirement for industrial scale application is important. As previously mentioned, baobab trees can almost be considered a finite resource because of its long regeneration time. Therefore, it is interesting to assess how many trees that would be necessary for industrial scale demands. With this purpose in mind, two different material flow analyses are presented in this section and the correlating calculation steps are presented in appendix F.

The purpose of the first MFA (presented in figure 16) is to understand how much fatty acids that can be produced from the baobab seeds that are currently generated from the pulp platform (as presented in section 4.4). The purpose of the second MFA presented in figure 17, is to understand how much baobab fruits and baobab trees would be needed to supply an industrial demand of 100 tonnes of fatty acids. The MFA in figure 16 displays that current supply of baobab fruit can generate 19-45 tonnes of cosmetic oils that can be processed into 15-36 tonnes of fatty acids. In addition, it is noticeable that the seeds are a substantial part of the fruit that will generate a lot of waste if not utilised. The variation of the output depends on the oil processing yield.

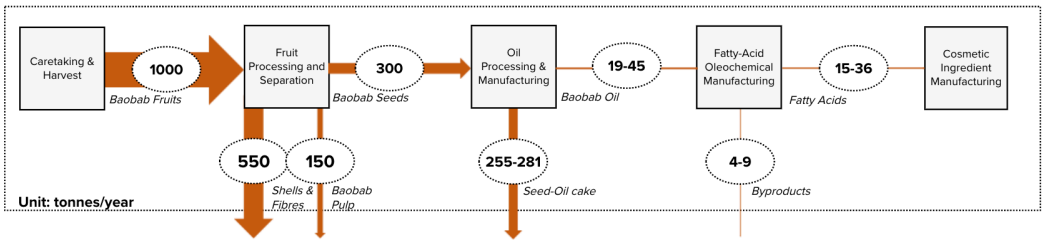


Figure 17 Material flow analysis based on the current annual supply of baobab seeds.

As mentioned in both table 6 and appendix F, the oil processing yield can vary between 6-15%. Similarly, Lykke et al. (2021) found that the oil content of the seeds varies between 13-22%. Therefore, it is of great importance to improve the oil yield to increase the final output of fatty acids from the product chain.

The number of fruits required to meet the industrial demand of 100 tonnes of fatty acids are presented in figure 18. As can be seen, it requires three to seven times more baobab fruits than the current baobab annual supply. Also in this scenario, the oil processing introduces great uncertainties where an oil yield of 6% would require almost 7000 tonnes of baobab fruits while an oil yield of 15% would require approximately 3000 tonnes of baobab fruits.

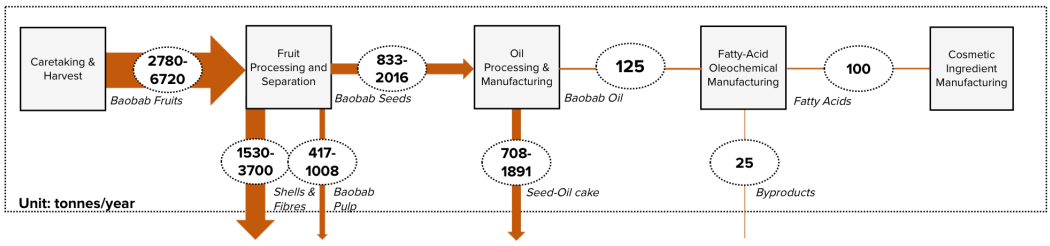


Figure 18 Material f low analysis based on an annual industrial demand of 100 tonnes of fatty acids

As mentioned, baobab trees can be considered as a near to finite resource as the trees regenerate very slowly. Therefore, it is important to understand how many trees are needed to supply a certain number of fruits. In table 6 below, the estimated number of trees required to supply a certain demand of 50-100 tonnes of fatty acids, or 50-100 tonnes of cosmetic oils are presented. The results show that around 56000 trees might be needed in comparison to enable an industrial demand of 100 tonnes of fatty acids. The current supply of baobab seeds from the pulp production is estimated to require 8200 trees. Still, the number of trees required to meet this demand is a rough estimate based on the average of fruits collected per tree. The amount of fruit collected per tree can vary significantly as it depends on tree productivity. Thus, the estimation of required number of trees will vary too.

Table 7 Scenarios for different demands of baobab based fatty acids and the required number of trees and fruits needed to meet the demand. The variation within each scenario depends on the oil yield of 6.2% or 15%.

Scenario	Fruits [tonnes]	Trees [number of]
19-45 t of Cosmetic Oils	1000	8200
15-36 t of Fatty Acids	1000	8200
50 t of Cosmetic Oils	1111-2700	9300-22400
50 t of Fatty Acids	1400-3400	11600-28000
100 t of Cosmetic Oils	2200-5400	18500-44800
100 t of Fatty Acids	2800-6700	23000-56000

Currently, the Ghanaian baobab tree population is unknown. But some estimates have been made for shea, suggesting a population of 94-100 million trees in Ghana (CBI, 2021b; Masters et al., 2004). More data on the baobab tree population is required to understand the scalability of baobab seed-oil as feedstock for cosmetic ingredients manufacturing.

The most significant assumptions made within the MFA is the average seed content in a baobab fruit. A sensitivity analysis that is presented in Appendix F shows that the oil yield impacted the result more than the seed content.

5.4 What Can we Learn from the PCO?

The current supply of baobab fruit has the potential to partly meet the expected demand. However, two important limitations exist: the uncertainties of oil yield and the existing baobab population. The oil yield data varies heavily and pilot test results are needed for more accurate estimations. The baobab population can be considered as a finite resource as explained in section 5.1.1. Since the baobab trees take several decades to produce fruit, the current population will limit the scalability. In addition, no approximation of the total baobab population in Ghana and Burkina Faso is found. Therefore, even with an approximation of trees required, as calculated in the MFA, it is nearly impossible to draw any conclusions of feasibility or scalability. The supply from the baobab sourcing platform could be a good starting point from which the demand could be steered.

A finding from the PCO is also that as baobab is a non-edible seed-oil, it could be particularly interesting for the cosmetic industry. Since the consumers now demand more sustainable cosmetics and personal care products, the non-competitiveness with food security could be highlighted as an advantage for baobab. In addition, the baobab seeds are under-utilized by-products in this case study.

All actors included in figure 16 are not interviewed in this study and are therefore not represented in table 8. However, they are included to enable a better understanding of the product chain. The identified actors who have been interviewed stress the importance of local capacity building, market demand creation, policy advocacy, partnership and collaboration as well as regeneration and conservation.

6 Perspectives on Sustainable Sourcing

What very quickly became evident during the investigation of actor perspectives on ethical and sustainable sourcing was the broad range of perspectives linked to these concepts. The full collection of insights provided by the various actors are summarised in Appendix G. As mentioned in section 2.1, the topic of sustainability is broad, and several definitions exist. The same can be said about sustainable sourcing. This was for example captured by the Sustainability Manager of the Evonik business line Care Solutions:

> *Sustainable sourcing to Evonik, to Care Solutions, to our customers and to me is all different.*

The fact that almost every interviewed actor, from the local NGO to the global cosmetic companies gave a similar reply shows the importance of asking product chain actors how they define sustainable sourcing. In addition, several interviewees highlighted the aspect of sustainability being a loose and a "fluffy" concept. One interviewee mentioned that sustainability is not and should not be a standard. Another interviewee was onto the same track and highlighted that sustainability is not a steady state, it's an ambition to which companies and society can work towards. This aspect was also mentioned by the local NGO who highlights that sustainability in sourcing is also about continuous improvement and measurement. Several actors mentioned that sustainable sourcing is to work towards the Agenda 2030 and implementing the SDGs. One interviewee particularly highlighted the difficult but crucial aspect to always integrate all aspects of the SDGs and not neglect or exclude goals. To really understand what is really at stake, the co-founder and CEO of the local SME Aduna highlights:

> *Aduna can't separate environmental sustainability from the human aspect. This is what we have in common with ORGIIS. You can't have environmental sustainability without sustainable communities and vice versa. Sustainability here is not CSR, it's about if people can generate enough income, have access to education and secure livelihoods.*

Some trends of what actors include when defining sustainable and ethical sourcing respectively are identified from the findings presented in appendix G. Fair trade was mentioned many times by actors when asked about ethical sourcing but never for sustainable sourcing. Fair pay and the value distribution was mention two times for sustainable sourcing and by every actor except one for ethical sourcing. Reducing inequalities and empowerment of women were also mentioned as ethical sourcing. In general, social aspects can be seen as dominant for ethical sourcing. Aspects related to the environment were mentioned much less for ethical sourcing but more often for sustainable sourcing. However, the preservation of ecosystem services was mentioned by one actor in relation to ethical sourcing. Traceability, respecting local structures and land tenure practices were also mentioned by some actors as a part of ethical sourcing.

For environmental sustainability, biodiversity, land degradation, and soil quality were frequently mentioned aspects. In addition, climate change resilience was mentioned by one actor. Other important aspects of environmental sustainability were regeneration

and sustainable resource use. The director of the local NGO described how they aim to promote sustainable resource use while contributing to people's livelihoods:

> *We need to find what we can do to make sure people have alternative livelihoods, to mitigate negative impacts on natural environment. The only available option we have for income opportunities for the people, are local resources that are available and that can be used without destroying the vegetation. The first product that came to our minds was shea, the second was baobab.*

For economic sustainability, most actors mentioned fair pay/wages and fair value distribution along the product chain. Although, few actors actually explained what fair wages or fair pay would mean more specifically. The most important aspect of economic sustainability appeared to be that the local communities receive their fair share of a product's value. In this context, transparency was mentioned by multiple interviewees and often in combination with certifications and labels. Throughout the interviews, two different certification standards FairWild and the Union for Ethical BioTrade Standard (UEBT) were mentioned. The FairWild standard provides guidance on best practices for commercial-scale harvesting and trading of wild-harvested plants. Within UEBT, many of the perspectives mentioned so far in this chapter e.g., respect of rights and practices of indigenous peoples and local communities, workers' rights, and biodiversity, are included. In addition to the perspectives just mentioned, the fair and equitable sharing of benefits derived from the use of biodiversity is highly incorporated in the UEBT standard. This principle is relevant to comply with ABS legislation mentioned in the theory chapter as a part of the Nagoya protocol. Moreover, the principle promotes fair compensation when using local resources as raw materials, e.g., in the cosmetic industry. The standard has defined critical criteria both in the cases of an existing ABS legal requirement and in the case of a non-existing requirement.

Local communities and traditional social structures were in focus for social sustainability. The most frequently mentioned aspects were land tenure rights, safeguarding existing small-holdings, and to respect traditional knowledge. These findings are interesting as social sustainability assessment tools rarely consider these aspects which was mentioned in section 2.1. As proposed by the lighthouse model by Holmberg and Holmén (2018), vertical relationships, i.e., the trust between individuals and institutions or governmental quality, can be included in the social dimension. However, good vertical relations were not stressed as often as horizontal relations. Although, compliance with laws where naturally touched upon by most of the actors, especially the larger companies. Still, the most frequently mentioned aspect of compliance was in fact to go beyond legislative requirements. A senior researcher from IVL explained:

> *Just because you follow the law does not mean that you do something positive for the societal development. What you compare your actions to and what your foundation is for statements on impacts is important.*

This statement can be linked to the four principles of sustainability mentioned in section 2.1 that are built on the un-sustainable nature of our society. While the four principles suggest what society shouldn't do to engage in sustainable activities, the actors instead suggest to go beyond compliance of laws that are insufficient to ensure sustainable

activities. In fact, the topic of sustainable and ethical sourcing did open for reflections concerning consumption and our global economic system. Sustainable and ethical sourcing could mean active engagement in the question on how to make the global economic system more sustainable, change consumption patterns and reduce inequalities in line with SDG10 as seen in figure 3. This was captured by the value chain expert from the UNCCD:

> *Our current consumption patterns are unsustainable. We consume more than we need, and more than the planet can provide. But should the people in Sahel really pay for the consumption patterns of industrialized countries?*

The UNCCD value chain expert further argued that it is better to source from species that thrive in the climate of Sahel as it provides additional income and generates incentives to conserve wild species. Similarly, other actors active in the region through operations or sourcing stated the same. In addition, researchers like Vermaak et al. (2011) argues in the same direction. The complexity of the global economy was also confirmed by the director of the local NGO interviewed. During the interview, the NGO director mentioned how foreign businesses enter the African continent with an intention to get free or cheap resources. He provided an example of how cocoa farmers can't earn enough income from their farm, so they sell their farmland to mining companies which completely change the use of the land in a way that negatively impact biodiversity and environment. In his perspective:

> *The only solution to the problem is that foreign interest isn't seen as more important than the survival of the people living on the land that supplies the resource.*

Another actor gave an example of how some companies bring their own labour force to collect fruits that doesn't even create work opportunities for the local communities. Such practices disrespect the traditional laws and regulations and might be a challenge for the increased commercialization of baobab fruits according to this actor. The importance to understand the local context was yet again stressed by the interviewed independent baobab expert:

> *If local communities are involved, they can create sources of income where they had none, and the rural areas can benefit from non-utilized recourses.*

However, to create a value chain from a non-utilized resource, a market demand needs to be created. Availability and existence of a sustainable market for indigenous products is a fundamental aspect of sustainable sourcing to the SME. In their experience, aid funded projects are common practice in the regions where they operate. In aid funded projects, a lot of money are invested in cash crops, training, tools, and equipment. However, the final products or crops might not even have a have a market. Without a market, it is impossible to create a sustainable, self-sustaining economy after the finalization of an aid funded project. To promote a more sustainable sourcing pathway, Aduna has over their 10 years of operation, developed a business model that they call "market demand creation model". By promoting this model, they aim to create a stable market for under-utilized indigenous products. The co-founder of the SME summarized this ambition:

To create self-sustaining economies, we need to focus on business plans, not project plans. Only by considering the value chain in its entirety and the needs of all actors within it, true, long term sustainability can be achieved.

However, one interviewee highlighted that even with an exciting market, there are two other aspects that are vital to take into consideration when discussing sustainable sourcing related to the region of Sahel. Firstly, the future of the value chain needs to be addressed as the Sahel will be hit hard by climate change and therefore it is important to include this aspect. Secondly, the value chain needs to survive the everchanging global demand. The value chain expert from the UNCCD did a similar observation but with a focus on the local people of Sahel. By the following quote she mentioned the need to adapt crops to the local context and not demand products from crops that won't survive the coming ten years of climate change effects in the Sahel:

We need to make sure that the crops used will still be alive in the next ten years and to not raise hopes and promises that will no longer be feasible in the future.

In addition to these overall considerations, private actors that want to invest in the Sahel region should focus on three main considerations: land rehabilitation, income generation to local population, and climate resilience. According to this actor, the route forward is to combine these three purposes for new value chains with local indigenous species. The local NGO had a similar suggestion. Private companies sourcing from the region should somehow engage in research, policy, and regeneration. The industry association had a similar take on the issue and encourages their members to engage in parkland regeneration together with women empowerment as key sustainability topics.

Community impact is mentioned as an important aspect of sustainability in one way or another by almost all actors. One actor stressed the importance to understand local communities, current ownership structures and land tenure in the area where the resource baobab and shea trees grow. Several actors have confirmed and stressed the importance of safeguarding traditional ownership structures. However, as there are no blueprints for ownership and land tenure rights when it comes to wild-grown trees, it can be quite complicated for non-locals to understand who has the right to pick what fruit and from what land area. Furthermore, it is important to understand the local context in order to understand who benefits from the new product or value chain. For shea and baobab, women are most commonly the ones collecting the fruits. For shea, women are also the ones that traditionally process the kernels to shea butter. By understanding the traditional practices, training can be adapted to women's needs and the values from shea can empower women. As the director from the Global Shea Alliance states,

Ethical sourcing is sourcing that does not take advantage of the women who collect and produce the resource.

Both the shea industry association and the local NGO promote capacity building and training for women cooperatives of both shea and baobab. Capacity building is also mention by Buchmann et al. (2010) as a mean to encourage sustainable and ethical trade of baobab fruits without neglecting baobab use in subsistence.

Another actor stressed the importance of non-exclusivity i.e., that the resource can be sourced by other private actors. Similarly, one actor stressed the importance to not compete with local use of the resources. For baobab, this concern has also been lifted by Buchmann et al. (2010) in relation baobab's listing as a novel food to the EU. However, both ORGIIS and Aduna mentioned that baobab generally and baobab seeds especially have a much larger local supply than local demand. Baobab seeds are crucial to the local funeral traditions, but only a small amount is needed. For shea, the global demand is seeing an increase. Still, GSA didn't mention any need to ensure local communities get access to shea. However, with an increasing demand for the two oilseeds, no one can predict exactly how the local access might change. Here, monitoring and measuring of impacts from sourcing activities have a key role to mitigate negative impacts on both social and environmental aspects. Several interviewed actors, especially researchers, mentioned the need to monitor and measure how sourcing activities affect sustainability parameters, especially environmental but also social aspects.

Another aspect of responsible business practises highlighted by the global B2B company is the role of large companies when initiating new collaborations. The role of large companies should be to provide clear requirements but also to understand how to disengage sourcing activities as a possible consequence of changing market requirements, without causing harm to small actors. Many of the actors covered the importance of partnership and trust in sourcing schemes with a set up similar to this case study. One actor mentioned the importance of gut-feeling i.e., knowing that a business has integrity and is sharing your values as an important aspect for trust. The global B2C company mentioned the importance of partnership by stating:

You don't have an impact if you are alone.

6.1 What Can we Learn from the Perspectives on Sustainable and Ethical Sourcing?

With regards to sustainable sourcing, it is suitable to connect back to the fact that sustainable sourcing has very different meanings depending on who you talk to. The definitions and perspectives gathered in this study range from very detailed level and specific environmental impacts to large complex questions related to our global economic system. Therefore, it is important to clearly specify what is meant by declaring something as "sustainably sourced".

To summarize the broad set of insights around perspectives collected from the product chain actors, we, the authors of this report, can see that most actors see sustainable and ethical as a basis for conducting business. It is not just about complying with current law and regulation, but to go beyond basic requirements and have transparency towards stakeholders. Some common definitions of sustainability were also highlighted by the actors. The Agenda 2030 and the SDGs but also the three dimensions of sustainability. Within the environmental dimension, the conservation and regeneration of indigenous species, parklands and agroforestry systems were in focus. For wild harvested species, it is evident that these aspects become crucial.

We can also see that ethical sourcing tends to include social aspects e.g., the respect of local structures, land management rights, and working conditions. Furthermore, there

were two aspects of ethical sourcing that were mentioned by all actors and experts interviewed, fair pay and trade as well as the distribution of value back to local communities supplying the raw material.

One observation that can be made from our perspective, is how the level of detail in the description of sustainable and ethical sourcing differs between the actors. In general, the local actors can clearly phrase what is important to them and the actors further away from the raw material source are more generic. This insight might not be very surprising, but further highlights the importance of inviting the local actors to create a clear understanding of local needs already in the design phase of a potential collaboration.

All in all, there are many aspects identified through the interviews with actors and experts that will accounted for in the feasibility study. In fact, according to the product chain actors, sustainable and ethical sourcing practices are not “nice to have” but need to be considered as fundamental for feasibility. In the next stages of the report, the term sustainability also includes the ethical aspects identified in this chapter.

7 Assessing Sustainable and Feasible Sourcing

To guide sustainable and feasible sourcing of a West-African indigenous seed-oils, an assessment framework has been developed based on the findings from earlier chapters. This framework is presented, explained, and tested in this chapter.

7.1 Outline of the Assessment Framework

This section starts where chapter 6 left off, by stating that sustainable and ethical sourcing practices are not a "nice-to-have" but a fundamental basis for business. Therefore, the assessment framework includes and integrates specially defined sustainability and feasibility aspects applicable for wild-harvested raw materials. As described in chapter 3, the framework is composed by study areas, information required to understand these study areas, and one or several criteria for each study area. The framework is based on a combination of feasibility studies as mentioned in section 2.2 and sustainability aspects from the interviews mentioned primarily in chapter 6 but also in section 5.2. The resulting study areas and their related critical questions and criteria can be found in table 8.

7.2 Guiding Sustainable Sourcing of Baobab and Shea through the Assessment Framework

In this section, baobab and shea are assessed for each study area and respective criteria found in table 8. The assessment of each study area will follow the same structure of fours steps. Firstly, the reason why the study area is important when assessing feasibility and sustainability of wild-harvested raw materials are feedstock for cosmetics is described. Secondly, the critical questions are presented. These questions function as a guidance to collect the necessary information for the assessment. Thirdly, the information for each question is provided based on the case of baobab and shea. Lastly, the activities that might be needed to sufficiently meet the criteria are presented.

7.2.1 Local Context

The importance of understanding the local situation when evaluating the extraction of a new raw material was highlighted by several actors in the product chain, especially the actors located in the start of the product chain. In addition, conventional feasibility studies (see section 2.2 and Appendix A), also include e.g., background information, a description of the geographical location, and environmental conditions. The following critical questions are answered to get enough information for the study area:

- What location(s) are relevant to investigate when evaluating the sustainability and feasibility of sourcing raw material?
- What are the local conditions and current site data?
- Is the country(s) of origin a high-stake country according to HDI?

The local context, the Upper East region of Ghana and Centre Sud of Burkina Faso is described in section 4.1 and is not repeated in this section. Due to its complexity, especially when it comes to land tenure and cultures, the partnership with the SME and the local NGO is important to truly understand the local context.

Table 8 The Assessment Framework.

Study area	Information	Criteria
Local Context	7.2.1	• Understand the local context
Land Tenure & Ownership Structures	7.2.2	• Protect and respect existing small holdings and traditional ownership structures
Conservation & Regeneration	7.2.3	• Understand and respect of nature's carrying capacity to provide the resource • Understand the wild species' material, non-material, and regulating contribution to people • Contribute to regeneration and conservation
Impact on Local Communities	7.2.4	• Identify what type of support the local communities need and want • Support local communities in line with these needs and wants • Ensure no negative impact on food security
Access and Benefit Sharing	7.2.5	• Apply ABS principles with or without formal legislation
Environmental Impact	7.2.6	• Improve or maintain soil quality • Improve or maintain climate change resilience • Improve or maintain biodiversity • Ensure zero deforestation or contribute to re-forestation
Women Empowerment & Capacity Building	7.2.7	• Empower women in the product chain • Encourage and support capacity building
Working Conditions & Health and Safety	7.2.8	• Ensure decent working conditions • Ensure sound health and safety practices along the value chain • Support health and safety training
Responsible Business Practices	7.2.9	• Ensure non-exclusivity to the raw material • Provide clear requirements of quality, volume, and sustainability of raw material and sourcing practices
Fair Pay and Value Distribution	7.2.10	• Pay a fair price for the raw material • Ensure that the value generated from raw material is distributed to the local communities • Provide work opportunities for local communities
Traceability & Transparency	7.2.11	• Assure traceability of the material origin, material flows, monetary flows • Present and prove material origins, material flows and monetary flows • Present how "sustainable" is defined in the context of the sourcing
Economic Feasibility	7.2.12	• Pay a reasonable price for the feedstock
Facilities & Capacity	7.2.13	• Ensure availability of oil-processing facilities • Identify available fatty acid processing facilities • Ensure enough capacity to meet volumes and quality for industrial scale
Logistics & Infrastructure	7.2.14	• Ensure sufficient and available storage • Ensure available transportation to all processing facilities • Ensure available shipping to Evonik facilities • Guarantee timely delivery
Operation & Management	7.2.15	• Engage in cooperation with local actors available to manage operations and deliver the required volume and quality
Applicability as Feedstock	7.2.16	• Identify applicability of feedstock for final cosmetic ingredient
Intentions & Ambitions	7.2.17	• Have a strong motivation for engaging in this unconventional sourcing scheme • Identify the connection to the SDGs

7.2.2 Land Tenure and Local Ownership Structures

Many interviewed actors identified the understanding and safeguarding of local land tenure rights, local communities, and ownership structures as important aspects for sustainable sourcing. Therefore, land tenure and local ownership structures are an important study area to consider, especially for wild-harvested raw materials. To fully understand the study area and enable an analysis of if and how the criteria could be met, the following questions are answered:

- What are the local land management and land tenure practices?
- Who manages access to the raw material and who has access today?
- Does the sourcing of the raw material threaten the existing traditional practices and access?

The current local land management, tenure practises, and access to the raw material are covered in section 4.2.4 and section 5.1.1. The sourcing of baobab currently respects traditional practises. As the director of the local NGO states, the local ownership structures are natural to him and to ORGIIS, but very complex to outsiders (J. Awaregya, personal communication, May 10th 2021). As ORGIIS understands these structures, it can make sure that sourcing of the baobab and shea fruits are in line with the local traditional values. However, as one actor stated, everything can change when money comes into the picture. Hence, it is important to also have an ambition to respect structures that have functioned well for many generations. By engaging in sourcing activities for baobab and shea with the local NGO, the criteria to protect and respect existing small holdings and traditional ownership structures for this study area can be met. Still, it should be carefully monitored together with other partners.

7.2.3 Conservation and Regeneration of Natural Resources

The area of conservation and regeneration of biodiversity and ecosystems was touched upon by several interviewed actors. In addition, the scientific community identifies this as a key concern for sustainability (IPBES, 2019; Lykke et al., 2021; Vermaak et al., 2011). To fully understand the study area and to enable an analysis of if and how the criteria could be met, the following questions are answered:

- What is the species' material, non-material, and regulating contributions to people?
- Would the increased sourcing of this raw material compete with local uses?
- How much raw material does the current population of the wild species generate?
- Would the increased sourcing create land use change and if yes, how?
- What is the status of biodiversity in the geographical area of sourcing?
- Would natural propagation be threatened by increased sourcing?

Some examples of current material, non-material, and regulating contributions from shea trees and baobab trees are listed in section 4.2.3. According to Aduna, ORGIIS, and literature findings e.g. Lykke et al. (2021) and Vermaak et al. (2011), baobab fruits and seeds are under-utilized resources with a higher supply than demand on both local and global markets. In fact, the seeds can be considered as a by-product from the baobab pulp production. Utilising the seeds from the pulp production would therefore not compete with local uses. However, as mentioned in section 5.1.6, baobab can almost be considered as a finite resource and with increased demand exceeding the seeds generated from the pulp production needs further analysis. Currently there is no

available estimate of the baobab population in Ghana and Burkina Faso. Therefore, it is not possible to calculate how much seeds could be generated from the current population. The scale-up potential is therefore difficult to analyse, and the topic requires further research.

Compared to baobab, shea kernels have a higher demand on both local and global markets. Still, several studies suggest that the shea is still not fully utilized, especially on a global market (Bockel et al., 2020). How the sourcing of shea butter or kernels would impact local use is however uncertain and can't be assessed based on the findings in this report. Estimates of the current shea population are mentioned in section 4.2.2.

As baobab and shea are both wild trees, no land use change should be expected. However, as already mentioned, increased demand might encourage more planting of seedlings. If the land use change through increased plantations of trees is positive or negative depends on how it is done. For example, if land would be cleared to make room for shea and baobab trees, the impact can be negative. However, if the plantations are done in agroforestry systems or on degraded land, the impact can be positive. Baobab seeds and shea kernels are important for natural propagation and regeneration. Increased sourcing of seeds for oil might therefore reduce the trees' ability to regenerate naturally. ORGIIS suggested to address this risk by leaving some fruit on the ground for natural regeneration or for private actors to actively engage in regeneration projects.

7.2.4 Impact on Local Communities

As described in chapter 6, many actors mentioned local communities and how increased sourcing might impact them. Just saying the words "community impact" does not say much. The impact can be positive or negative, be in line with the wishes and needs of a local community or be forced and based on false perceptions of community needs. Therefore, this aspect is considered an important study area. To better understand the study area and enable an analysis of if and how the criteria could be met, the following questions are answered:

- How can sourcing of the raw material impact local communities, positively and negatively?
- Can the sourcing impact food security?
- How can actors positively contribute to the local communities?
- What type of support do the local communities need and want?

Positive impact on local communities from sourcing activities of baobab and shea are income generation through the sales of fruit or oil products, work opportunities, and conservation of ecosystems through the increased value of indigenous trees. Both ORGIIS and GSA mentioned the need to focus on research, regeneration, and policy advocacy. Here, research contributes with e.g., plantation practices for baobab seedlings. Negative impact on communities can include reduced natural propagation of new trees if too many fruits are collected. In addition, reduced access to seeds can impact cultural and traditional uses. Baobab seeds are still used as a part of funeral ceremonies. Since the ceremony only requires very small amounts of seeds, increased commercialization will probably not disturb this application.

The increased commercialization of baobab seeds would not negatively impact food security as the baobab oil is not suitable for consumption due to the CPFA content.

Shea butter, however, is an edible oil and the second most important fat on the African continent. This indicates a sustainability advantage for baobab seed-oil if compared to shea. To increase commercialisation of baobab seed-oil can increase local income and will not compete with food security. These two aspects could be attractive to cosmetic consumers and could be communicated clearly.

The second question of this study area indicates how the sourcing structure might affect the impacts. However, to completely understand how sourcing of a raw material might impact local communities is complex as it covers many different interconnected aspects and externalities. Instead of understanding everything completely, it might be best to ask how the sourcing can support to the local communities in best possible way. The local NGO mentioned that private actors can support in research, policy advocacy, and regeneration. To apply access-benefit-sharing programs within the sourcing activity enables local communities to benefit from the genetic resource either through monetary or non-monetary activities.

7.2.5 Access and Benefit Sharing of Genetic Resources and Traditional Knowledge

This study area is included in the assessment framework as its importance was highlighted by the B2B actor Evonik as a legal requirement that will be increasingly enforced by respective legislative authorities. In addition, the essence of the ABS framework is also mentioned by almost all actors, i.e., that the value and benefits generated from local resources are shared with the local communities. The ABS concept is also included in the certification standards FairWild and UEBT. To better understand the study area and enable an analysis of if and how the criteria could be met, the following questions are answered:

- Is the country of origin a party to the Nagoya protocol?
- Does the country of origin have an ABS legislation in place?
- Can the raw material under investigation be classified as a genetic resource or include traditional knowledge according to the CBS definition?
- With ABS legislation, what actions are needed to comply?
- Without ABS legislation, what actions can be taken to ensure access and benefit sharing according to the Nagoya protocol?

As presented in section 4.1, both Ghana and Burkina Faso are parties to the Nagoya protocol but currently do not have an ABS procedure in place. With the current level of implementation, there is no obligation in law to have a prior informed consent and mutually agreed terms regarding the use of genetical resource. However, it is still possible to make sure that access and benefits from baobab and shea are upheld according to the ABS framework. To meet the criteria of access benefit sharing in table 8, an agreement with local communities is recommended.

7.2.6 Environmental impact

The environmental impact of sourcing the raw material was mentioned as an important factor by all interviewed actors. Mostly, the concerns were regarding the impact from harvesting while one actor mentioned the importance of keeping a lifecycle perspective. Environmental impacts from sourcing are therefore identified as an important study area for the feasibility and sustainability of the sourcing. To fully understand the study

area and enable an analysis of if and how the criteria are met, the following questions are answered:

- How will the sourcing of the raw material impact soil quality?
- How will the sourcing of the raw material impact and/or be impacted by climate change?
- How will the sourcing of the raw material impact biodiversity and ecosystems?
- How will the product chain impact the environment based on all process steps?
- How will the sourcing of the raw material impact land use?

Both shea and baobab are important species in their ecosystem as they contribute with many immaterial, material, and regulating services as presented in chapter 4. For example, they contribute to improve soil quality, sequestration of carbon, and create a habitat for many different species as key species in gallery forests. By sourcing raw materials from the trees, their value increases and hence also the incentives to care for the trees. Thus, the sourcing has the potential both to maintain the aforementioned contributions from the trees and to ensure zero-deforestation. Biodiversity in the area is not analysed in detailed in this study and would require further analysis.

The region of interest will see increased temperatures and changed rain patterns due to climate change and thus increased risks of desertification. One of the purposes of the Great Green Wall initiative is to fight desertification by planting trees. Endemic species like shea and baobab will play a crucial part in this fight. To engage in regeneration activities within the GGW can potentially fulfil criteria within this study area.

Conducting a full life cycle analysis (LCA) could be a suitable next step to assess the full environmental impact of the product chain. Moreover, as the fruit is wild growing, it could be interesting to compare to a cultivated raw material. Unfortunately, a LCA rarely includes land use change and biodiversity loss within its framework as these aspects are difficult to quantify (van der Werf et al., 2020). Therefore, a complimentary assessment would be necessary.

7.2.7 Women Empowerment

Women empowerment was identified as a study area since both shea and baobab are collected by women. To fully understand the study area and enable analysis of if and how the criteria could be met, the following questions can help to guide the information needed:

- Are women in the product chain encouraged to join organized groups and/or cooperatives that improve their power?
- How are democratic governance structures encouraged within the product chain?
- Are there training opportunities for women in the product chain?

The cooperative union model and capacity building established by ORGIIS is described in section 4.4. This process includes empowerment of women cooperatives through training in e.g., business skills and quality requirements. By collaborating with ORGIIS, the criteria for this study area are fulfilled.

7.2.8 Working Conditions and Health and Safety

Working conditions as well as health and safety have been mentioned by several actors interviewed. Moreover, the area has been identified by the GSA as a key sustainability aspect for the shea value chain. The associated questions for this study area are inspired by the GSA sustainability program (Global Shea Alliance, 2020). These questions are defined below:

- How can compliance with national laws and international standards on child labour as defined by the ILO be ensured?
- How can no forced or bonded labour be ensured?
- How can no discrimination be ensured?
- How are safe and hygienic working environments promoted for all involved in the product chain?
- How is freedom of association, collective bargaining for workers, and collector/processor associations encouraged?

This study area has not been investigated within this master's thesis. Thus, no current information can be provided for these questions based on the interview findings or literature findings. This does not mean that the criteria are not fulfilled within the current sourcing platform, only that we as authors of this report have not specifically asked the questions to the actors.

7.2.9 Responsible Business Practises

How to operate responsibly in a product chain with large global actors and small local actors was highlighted as a key topic by actors like Evonik, ORGIIS and UNCCD. To better understand the study area and enable an analysis of if and how the criteria could be met, the following questions are covered in this section:

- Can non-exclusivity be guaranteed for the raw material?
- How are requirements of quality, volume, and delivery time agreed upon?

Exclusivity was highlighted by Evonik as an aspect to consider when conducting special sourcing procedures involving close collaboration with one supplier. Especially, Evonik does not want exclusivity as it hinders other actors in the product chain to conduct their business. Overall, sourcing baobab or shea through a partnership with Aduna and ORGIIS would require going beyond normal standard procurement procedures for an actor like Evonik.

To manage requirements of quality, volume and delivery, the local NGO highlights the importance of contracts early in the initiation of new collaborations. Contracts provide a security for the collectors and ORGIIS.

7.2.10 Fair Pay and Value Distribution

Fair pay, fair wages, and fair value distribution were mention by almost all actors during the interviews. These aspects were mentioned as a key for ethical sourcing. To fully understand the study area and enable an analysis of if and how the criteria could be met, the following questions are answered:

- How would sourcing of the raw material impact income generation for the local communities that harvest and/or collect the raw material?
- What would be a fair price for the raw material?

- What does the value distribution of the full value chain look like?

The baobab fruit price is currently based on the final price for baobab pulp as presented in section 4.4. To acquire the certifications FairTrade and FairWild, a premium of 10-15% need to be added to the final market price, which is similar to the premium provided by Aduna to the local communities that collect baobab (see figure 14). Based on this, the price for baobab fruits within the current baobab pulp sourcing platform could be considered fair according to existing certifications. By creating value to the baobab seeds, an increased price can be paid for the fruit. Moreover, if the oil-pressing is conducted by the local communities, even more value can be generated through new work opportunities. Currently, Aduna does not source shea kernels or shea butter. To source shea from the women cooperatives that already provide baobab could generate increased income to these women. Moreover, shea and baobab seasons complement each other over the year as presented in table 4. Thus, Aduna would be able to generate work opportunities throughout the year through their processing facilities in Paga. Within this study area, it might be suitable to consider sourcing baobab and shea in combination for increased sustainability.

The capacity to process shea butter in Ghana and West-Africa is good according to both GSA, ORGIIS and research. Thus, to source shea fatty acids that is derived from locally produced shea butter could contribute to local communities more than to source shea based fatty acids that are derived from production outside of West-Africa. To engage sourcing raw materials in collaboration with Aduna and ORGIIS, middlemen are reduced which can ensure that the value is distributed to the local communities.

7.2.11 Traceability and Transparency

Transparency is one key aspect highlighted by most actors interviewed in relation to sustainable and ethical sourcing and is therefore included as a study area important to consider in the assessment. To better understand the study area and enable an analysis of if and how the criteria could be met, the following questions are answered:

- Can the raw material be traced to its country of origin?
- Can the raw material be traced all the way down to collecting cooperative?
- What is defined as sustainable sourcing by the actors involved?

The number of actors in the product chain very much regulates traceability of a raw material. The product chain identified in this study have few middlemen and no traders between receiving company and raw material supplier. See section 4.4 and 5.2 for a better overview of the product chain and related actors. Sourcing raw material directly from an SME like Aduna enables efficient tracing of the material. However, seeds from Burkina Faso and Ghana might get mixed in the fruit processing step. As described in chapter 6, the definitions of sustainable sourcing differ and align among the actors. Therefore, clear and transparent communication on the definition of the term “sustainably sourced” is recommended.

7.2.12 Economic Feasibility

In similarity to other more “practical” feasibility areas, the economic aspect, meaning the cost and price of oil and fatty acids derived from baobab and shea is crucial for both feasibility and sustainability. The following questions are answered:

- What would the price be for the baobab-based oil?

- Does it make economic sense to source the baobab-based oil?
- What would the price be for the baobab-based fatty acid?
- Does it make economic sense to source the baobab-based fatty acid?

Currently, there is a market price for shea butter and fatty acids derived from shea. However, baobab is not commercialised in the same sense as shea and a price for oil and fatty acid needs to be investigated. The price for shea kernels, shea butter, and shea based fatty acids could function as a reference for the price of baobab seeds, oil, and fatty acids. This analysis is not done in this study but will be carried out as a supplementary study.

7.2.13 Facilities and Production Capacity

One of the core aspects of the feasibility assessment is to clarify if oil processing facilities available have the capacity for the intended application. Therefore, the study area of facilities and production capacity is included. The following questions are answered:

- Are there any fruit processing facilities available?
- Are there oil processing facilities available and if yes, what is the capacity?
- What is the reliability and availability of oil production facilities?
- Are there any alternative production pathways for oil possible?
- Is the power supply sufficiently reliable for local oil processing?
- Are there any fatty acid production facilities available and if yes, what is the capacity?

The questions on available facilities have been answered thorough the case study. The strategy to implement product processing locally is mentioned several times in this section already as a means to capture value and distribute it to local communities. This is mentioned in section 2.3.3, through the concept nature pays from WWF, and in conversations with the local NGO and SME.

The oil processing facility in Kumasi is according to the director of the local NGO the only viable option in Ghana for the type of processing required in this case study. The pressing equipment used by this contractor is from the 1960s. In addition to this, the facility might not be able to use to produce organic products since it is commonly used for palm oil production. As a consequence, the baobab seed-oil might have traces of pesticides (J. Awaregya, personal communication, May10th 2021). The cost for transport and oil-pressing at the contractor is high and therefore not a good alternative in the long run. To invest in an oil processing facility in Paga would be an alternative approach to reduce these high costs.

As shown in table 2 in section 4.1, the access to electricity in the rural parts of Ghana is much lower than in the cities. Moreover, the power supply is not very reliable according to both ORGIIS and Aduna. In fact, during the second interview with the local NGO, there was a power shortage. In addition, power shortages were mentioned as a challenge to the baobab pulp processing by the SME. Cold pressing usually requires a screw press that relies on electric power. If the oil processing of baobab oil should be moved to Paga, some investments might be needed to ensure reliable electric supply.

In terms of local shea production, the case is currently slightly different to baobab. To extract shea butter, the traditional method is mainly used and can be done by women in local communities without any pressing facilities. However, as mentioned in section 5.1.3, there are some downsides with the traditional method. Some alternative oil extraction methods could be explored to for example increase yields, improve working conditions and reduce resource use.

With regards to fatty acid production, there are many producers available globally. However, if a smaller quantity is required for production from a speciality source such as baobab, there are not as many alternatives remaining. The process of extracting FAs generally requires large production facilities to ensure economy of scale. It is not a feasible alternative to find a fatty acid extraction facility locally in Ghana or Burkina Faso. Instead, commissioning an already established fatty acid producer outside the African continent is suggested.

To conclude, the current capacity of local oil processing is a bottleneck for baobab seed-oil. An investment in an oil pressing facility/machinery could be a necessary step to ensure local production of seed-oil. There are also interesting examples of a simplified shea butter extraction method that could be interesting to further investigate if shea is to be integrated within the baobab sourcing platform.

7.2.14 Logistics and Infrastructure

Logistics and infrastructure are included as a study area as it is frequently mentioned by actors such as the local NGO, the SME, and Evonik. Within logistics and infrastructure, the detailed aspects mentioned are storage, transport, and shipping. To fully understand the study area and enable an analysis of if and how the formulated criteria could be met, the following questions are answered:

- How can sufficient regional transport to and from the fruit processing facility be ensured?
- Are there any constraints to how the raw material is stored before processing?
- Is there any risk that the oilseeds or the final oil can deteriorate during storage?
- Is there transport available to and from the oil processing facility?
- How can export be managed optimally?

As Aduna and ORGIIS manage a functioning sourcing platform for baobab pulp, most of these questions listed can be considered answered. However, more storage facilities are needed with increased amounts of seeds. In addition, the facilities need to preserve the quality of the seeds. Moreover, the oil needs to be stored in air-tight containers to reduce risks of deterioration. The local NGO emphasizes that the logistics is one challenge for the scale-up of oil production as it is expensive. ORGIIS further mentions that time management in West-Africa is generally not perceived in the same way as in Europe. Therefore, the role of ORGIIS is to manage expectations between all parties.

ORGIIS and Aduna manage the local transportation. Thus, to engage in sourcing activities in collaboration with Aduna and ORGIIS ensure transport and shipping on time. However, the high cost of long-distance transport is a restraining factor that can limit the possibility to ship seeds to a pressing facility in Kumasi. Contracts with both ORGIIS and Aduna can help to guarantee accountability as ORGIIS has the contact

with local communities and Aduna with shipping companies as well as other logistical aspects.

7.2.15 Operation and Management

Operation and management are identified as a study area as they are mentioned in all feasibility frameworks as can be seen in appendix A. To fully understand the study area and enable an assessment of if and how the formulated criteria could be met, the following questions are answered:

- What local manpower and knowledge is available to meet the requirements linked to the sourcing of raw material?
- Is there any recruitment or training needed to enable souring of raw material on an industrial scale?
- Is there an organization available to manage the local activities when sourcing the raw material?

The local processes, manpower, and knowledge available have been covered in section 4.4 and chapter 5. To meet an industrial demand of 100 tonnes fatty acids per year, more baobab seeds will be required than currently provided as by-product from the baobab pulp production. ORGIIS estimates that it takes approximately two years to build an additional cooperative that can complement the supply of the required quality and volumes of baobab fruits. Thus, to meet even higher demands of baobab seeds, as presented in the MFA, the formation of new cooperatives need to be initiated soon. If the baobab seeds are sent to Kumasi for oil extraction, no further education is needed for the oil processing stage. In a scenario where the processing is done in the facilities in Paga, the operators might need training. Shea is not a part of the current sourcing platform presented in section 4.4. Thus, both quality training, and technical knowledge of shea butter processing, might be needed.

By engaging in sourcing activities that include the local NGO, a local actor is available to manage operations and deliver required volume and quality for both baobab and shea. As already mentioned, ORGIIS also takes contractual responsibility. In future scale-up scenarios, there might be the need to involve more actors, especially if regions where ORGIIS is currently not operating need to be included.

7.2.16 Applicability as Feedstock

The applicability of baobab and shea seed oils as a fatty acid or cosmetic oil is quite obviously important for the feasibility of the project. However, what counts as applicability can vary. The SME wants to understand the chemical feasibility of baobab and shea as the intended cosmetic ingredient. For the global B2B specialty chemical company, it is important that the wild-harvested product will contribute to the transition of Care Solutions' product portfolio and to meet future consumer demands for sustainable cosmetics. The following questions are identified to understand the information needed for this study area:

- Is it chemically possible to use the raw material for the cosmetic ingredient?
- Is it possible to derive the final product through green chemistry processes?
- Is it possible to derive the final product without chemical modification?
- Are any hazardous materials used in any production steps?
- Are any genetically modified crops (GMO) used?

- Will the final product be biodegradable?
- Will the final product be predominantly natural based or fully natural based?
- Will the final product be mainly based on second generation feedstocks?

The above-mentioned questions are not possible to answer through this thesis. Although, as shea butter is already used in cosmetics it can be considered applicable, both as cosmetic oil and fatty acid. Baobab seed-oil holds similar properties to shea and has traditional uses in cosmetics. The pilot study mentioned in section 1.4 will be important to collect further information to assess the applicability of baobab.

The other questions of this study area are primarily related to the end use and other feedstock that goes into the final cosmetic ingredient. A future challenge might be to explain how these are fulfilled to consumers and customers. Therefore, certifications and labels can be a good option.

7.2.17 Intentions and Ambitions

The aim of the last study area is to create an incentive for the involved actors to understand their own and the other actors' motivation to engage in the sourcing. The understanding of the intentions creates an ethical standpoint. As presented by Meadows (1999), ethics can transform intermediate goals such as consumer goods into meeting the ultimate goals of human needs. Therefore, to engage in sustainable and ethical sourcing, the actors themselves need to understand their own ethics. The aim of the following questions is to inspire to reflection as a part of the decision-making process when evaluation sustainable sourcing of a raw material:

- Why do we want to source sustainable raw materials?
- Why is this resource evaluated as a future product in the product portfolio?
- How does the sourcing impact the Sustainable Development Goals?
- How will the partnerships within this sourcing scheme be nurtured and respected?
- Are there any proven sustainability advantages from harvesting and/or processing when sourcing wild-harvested raw material as feedstock for cosmetic ingredients?

Each actor's motivation to engage in this sourcing scheme have been briefly described in section 4.3. Their intentions are also integrated in chapter 6 in where the actors describe sustainable and ethical sourcing and in section 5.2 where the actors describe their scope of action and involvement in the product chain.

7.3 What can we learn from the assessment framework?

As the previous section 7.2 provides a large set of information, a summary with key takeaways is presented here. The assessment framework is not standardised in any way but rather created to enable an understanding of what is important. With this as a basis, actions can be taken to make sure that the potential sourcing structure is both sustainable and feasible. Some criteria will be fulfilled simply by engaging in a special sourcing scheme with the actors ORGIIS and Aduna while some require more proactive engagement. An overview of the status for each study area for baobab and shea in the specific context of this study, is presented in table 9.

From the study areas, it is evident that nature and local communities are repeatedly mentioned together in several criteria and study areas. They are interconnected, you can't impact one without also affecting the other.

The avoidance of middlemen between the sourcing company and the collectors is highlighted several times as a key to unlock several positive benefits. Collaborating with a local NGO or SME can be a way to avoid middlemen such as traders and retailers. Traceability, an ability to impact the value distribution, working conditions and an understanding of community needs are all examples of aspects that could be realised through less middlemen.

It is hard to evaluate baobab and shea together as their status and level of commercialization is widely different. However, the criteria are applicable for both as they are wild harvested species growing in the same area. One area where the required development pathway can differ is the oil processing method. For baobab, cold pressing is clearly the best available option if the processing is to be carried out in the local communities. For shea, the traditional method has both pros and cons and there are several alternatives for development. Resource availability including tree population is also an area where the two species differ in the assessment. Knowledge and research about the natural resource are available for shea while it is a gap in research for baobab.

In the end, it is up to the involved actors to evaluate and decide if and how the criteria are to be used. We, the authors of this report, would like to present four examples of how to use the criteria:

1. **Define** what the claim "sustainable and ethically sourced" cosmetic ingredient means to consumers, customers, and other stakeholders. As presented in chapter 6, perspectives on sustainability varies depending on who you ask. By presenting how "we" define sustainable, other stakeholders can choose to agree or disagree. In fact, the criteria are formulated to answer: "When sourcing sustainable wild-harvested feedstock, we…".
2. **Assess** how many criteria that can be fulfilled today. As previously presented for each study area, some activities can be fulfilled today, and some might not.
3. **Identify** future activities and early partnership needed to fulfil the criteria. One example of a future activity for feasibility would be for Aduna and ORGIIS to identify and involve more communities to meet the demand. However, for Aduna and ORGIIS to initiate this work, mutual agreements and trustful partnership are necessary as it requires work and investments.
4. **Communicate** the complexity related to sustainable sourcing of indigenous West-African seed oils as feedstock for cosmetic ingredients. As noticed, this is a complex issue that involves many feasibility and sustainability aspects. By boiling this complex subject down into study areas and criteria, the complexity is more easily communicated, similar to the Agenda 2030 SDGs.

We would like to argue that perhaps it is best to initiate the sourcing, evaluate impact, and take action to improve impact instead of waiting for the best possible moment i.e., fulfil all criteria from the start. Through partnership and trustful dialogues, it could be possible to solve problems as they come instead of backing out from an opportunity with some loose ends.

If an actor like the B2B speciality chemical company in this study engages in sourcing baobab and shea and uses the criteria formulated in this study, indicators to enable measurement and tracking of progress would be recommended. There are also several aspects that would need further analysis, for example the actual price for oil and fatty acid, mapping of biodiversity in the area (e.g., number of red listed species) and oil processing techniques to further benefit the local communities.

So, can sustainable sourcing of baobab and shea be a way to combine commercial activities with socio-ecological engagement? Table 9 below presents the different study areas and how different activities ensure fulfilment or are further necessary to fulfil the criteria in each study area. From the table, it is not possible to state "yes go ahead" or "no don't go ahead" with the sourcing. Instead, it provides an understanding of what activities that enable sustainable and feasible sourcing. Based on the findings in this study, it is clear that sourcing of baobab and shea could enable increased income to local communities, conservation of indigenous tree species, and the support of rural livelihoods. These three aspects have generally been highlighted as key for sustainable sourcing and have clear synergies among each other. The sourcing scheme suggested in this case study and especially in chapter 5, is quite unusual as it combines a large-scale specialty chemistry company, a small-scale food SME, and a local NGO with very few middlemen.

Table 9 Summary of assessment insights.

Study area	**Key takeaways**
Local Context	Collaboration with local actors who understand local context is key
Land Tenure and Ownership Structures	Collaboration with local actors who understand local context is key
Conservation and Regeneration	The contributions of baobab and shea are understood though the NCP analysis Contribution to conservation but regeneration requires more active engagement. More research is needed to understand availability of baobab and shea trees to enable scalability analysis
Impact on Local Communities	Identify individual community needs and wants continuously Examples of identified needs are support in policy, research, and regeneration Usage of baobab seeds does not compete with food security
Access and Benefit Sharing	In Ghana and Burkina Faso there are no implemented legislative measures for ABS An ABS agreement should still be established to ensure access and benefit sharing which can also benefit private actors as this will be required more frequently in the future
Environmental Impact	To improve soil quality, climate resilience, and biodiversity, regeneration is needed To maintain soil quality, climate resilience, and biodiversity, conservation is needed
Women Empowerment and Capacity Building	Local product chain empowers women through income generation education and formation of cooperatives
Working Conditions and Health and Safety	This area needs further evaluation
Responsible Business Practices	Unconventional partnerships and sourcing procedure required between global actors and local actors
Fair Pay and Value Distribution	The existing sourcing platform provides fair pay which can be verified by a certification like FairWild Value distribution in value chain require further analysis
Traceability and Transparency	Possible to trace material flow, material origin and monetary flows The next steps are to communicate and verify This assessment framework can be used to define sustainable sourcing
Economic Feasibility	Needs further research
Facilities and Capacity	Existing facilities exist but to ensure feasibility of local processing, further investments are needed
Logistics and Infrastructure	Collaboration with local NGO and SME will fulfil parts of criteria Investment needed for increased storage capacity
Operation and Management	Local actors and more personnel available With new processing techniques training might be needed
Applicability as Feedstock	Further research needed
Intentions and Ambitions	Actors involved have strong motivations for engaging in this unconventional sourcing scheme Connection to SDGs need to be evaluated further

8 Discussion

In this chapter, we, the authors of this report will discuss the method and results, comment on potential future research, and share some general reflections on our work and role as engineers.

8.1 Discussion of the Method

The PCO method has been used as an intermediate means to find our study areas and to understand the enabling actors for the product flow. Therefore, it might have suffered from not having our full attention. More actors could have been interviewed and their interactions and power structure among each other could have been mapped. However, for its intended purpose as a "tool" to finally be able to assess baobab and shea as potential raw materials, we have found it to be very helpful.

The MFA contributes with a quantitative analysis to our study. Understanding the availability of resources for potential scale up is crucial in our study and for this, the MFA has been very useful. The MFA results are presented as a range due to variations of several important variables (e.g., oil yield, oil seed content, baobab fruits per tree) used in the calculations. The ongoing pilot study will provide valuable data on fatty acid composition, oil content and oil yield through that could enable more reliable results.

We have used the concept of "nature's contribution to people" (NCP) in this report. The eighteen contributions and related indicators suggested by IPBES is a good foundation for assessing the importance of indigenous species as it also takes immaterial contributions into account. However, since the NCPs are relatively new, it has been hard to find similar studies that apply the framework on indigenous species. To use the NCP framework, gave us a good understanding of trees that none of us have ever seen. We believe that a more thorough analysis of indigenous tree species through the lens of NCPs could provide an even better understanding of the synergies between local communities and indigenous trees.

The case study is based on conversations and interviews with local actors in combination with a literature search. To really capture the local context and understand the perspective of the women collectors, a trip to the region of focus would have been beneficial. During the timeframe and scope of this thesis, it was not possible to make a field trip to Ghana or Burkina Faso, mainly due to the Covid-19 pandemic. In general, using interviews in a case study can have both strengths and weaknesses. A few strengths listed by Yin in his book "Case Study Research" is that interviews can be both targeted, with direct focus on the study topic, as well as insightful in the sense that they bring both explanations as well as personal views. A few weaknesses mentioned are bias, both in terms of questions asked but also in the response from the interviewees. Inaccuracy can also become a problem when summarising or trying to recall interview insights. The final weakness important to mention is reflexivity, meaning that the interviewee gives the answer she or he beliefs the interviewer wants to hear. In this study, reflexivity is not perceived to be a problem as all interviewed actors have been keen to give their perspectives on the issues at hand.

The method of this master's thesis has been iterative, mainly qualitative, and empirical. The workflow allowed an exploratory approach in finding important actors, perspectives, and study areas. Broad and unexpected answers have been allowed through the open questions through the semi-structured interviews. However, our qualitative approach poses a risk of unconscious bias during the analysis of the collected data. Still, we want to stress that qualitative data have been highly valuable to approach this broad scope from a system perspective.

8.2 Discussion of the Results

One of the main findings from our work is the value of taking the time and effort to understand the local context and its complexity in a qualitative manner. This is clearly shown by the criteria in the assessment framework as many of the criteria focus on the actual understanding of each study area to also understand the impact that sourcing a raw material can impose. When we started this master's thesis, we had an ambition to create criteria to which the involved actors like Aduna and Evonik would be able to answer yes or no. The number of yes and no would then be summarized where a majority of yes would mean "Yes, it is feasible and sustainable to source baobab and shea as feedstock for cosmetic ingredients" or vice versa. However, we soon realised that this subject is too complicated to simply answer with a "yes go ahead" or a "no don't go ahead". Instead, we noticed that there is always more to learn, more to include, and more aspects to understand.

As highlighted in section 7.3, the assessment framework is not a final blueprint for sustainable and ethical sourcing. More study areas and criteria can be added depending on local context and how it is intended to be used. For example, if the status of the sourcing changes from pre-study to implementation or operation, the framework could be modified to serve a new purpose. One such modification could be to extend the list of criteria with a layer of indicators to enable measurement and monitoring of the impact of sourcing.

It is interesting to discuss if the assessment framework, that is primarily built on sustainable sourcing of shea and baobab, is in fact applicable to other West-African indigenous seed-oils. Since we have asked actors how they define sustainable and ethical sourcing, the study areas could be considered applicable to sourcing in general, not only the sourcing of baobab and shea. The interviewed actors might have been biased by the context, but still their answers were often quite general and broad. Furthermore, the criteria in the assessment framework are formulated to focus on understanding, which is arguably important for all sourcing. In addition, cultivated species could potentially also be evaluated through the framework since land-use and land-use change are considered within e.g., the study area "Environmental impact". We would therefore like to argue that it is possible to use the framework to guide sustainable and feasible sourcing of other indigenous West-African seed-oils too. However, some adjustments and additions might be needed to integrate relevant actor perspectives within the specific product chain.

Ecosystems and biodiversity have been mentioned briefly throughout the study, which is quite natural as they are fundamental for genetic resources. Biodiversity is in itself a very complex topic that could deserve a further analysis. In our case, an assessment of biodiversity in the local geographical areas where baobab and shea grow could be a good start. We would like to argue that it is important for companies to understand their

reliance and impact on biodiversity to truly be sustainable, especially when sourcing plant-based ingredients.

The approach of asking interviewees to describe what both sustainable and ethical sourcing means to them have generated interesting results. Fair trade, fair pay and fair value distribution along the product chain were defined as ethical aspects. If the question around ethical sourcing would not have been asked, we would never have received the full scope of insights that later generated study areas and criteria. A speculation on why this is the case is the strong brand of FairTrade. To us, it becomes quite clear that sustainable sourcing is also ethical sourcing and vice versa. For example, it can't be considered ethical to exploit a natural resource and it can't be considered sustainable to pay an un-fair price for the resource.

8.3 Future Research

The sustainable market demand creation model that Aduna has pioneered over the last decade has been briefly described in this report. However, no study has been made to understand what makes it or breaks it except Aduna's own learnings. It could be of both scientific and commercial interest to further define this business model. By defining this business model, other businesses can adopt a similar approach which is of interest to Aduna as they want the model to spread. From a research perspective, the model can be seen to combine the three dimensions of sustainability and would be an interesting model to promote if it truly contributes to conservation of natural resources, improved livelihood to local communities, and a functioning business model.

Access and benefit sharing is a relatively new legislation, and procedures to operationalise it are not well-established for neither private actors nor governments. To develop an ABS agreement within the context of this master's thesis topic would be interesting as it could function as a benchmark for future procedures and guidelines.

The topic of regeneration is both important and complex. There are several ways of approaching regeneration of baobab and shea including natural propagation and organised plantation of seedlings. More research is required within the field to find the most suitable approach. In addition, more research is needed to identify the current baobab population to be able to identify the full scalability of baobab based cosmetic ingredients.

For further understanding of the PCO, collectors and members of local cooperatives should be interviewed. This would bring additional depth to the PCO and more local perspectives to the assessment framework. Moreover, an LCA could complement the PCO and provide a good foundation when comparing the environmental impact from a cosmetic ingredient based on baobab and shea to other raw materials.

This section cannot be finalized without mentioning the aspect of economic feasibility. As specified in section 7.2.11 as well as in section 1.4, economic feasibility is defined as out of scope for this study. However, for the sourcing of baobab to be truly feasible and sustainable, the price of the resulting oil and fatty acid needs to be commercially viable. If it is too high, there will be no market for the final product. How the price of shea based fatty acids and cosmetic oils would change with more processing conducted locally also benefit from further research.

8.4 General Reflections

This master's thesis has quite naturally made us reflect on sustainability, ethical issues, and aspect related to our role as engineers in society. In this section we would like to openly discuss and present these reflections as they have played an integral part of our work, both on a professional and personal level.

As Meadows (1998) present in the Balaton Group's conceptual model of sustainability, ethics is crucial to go from human-made capital to human well-being. This is interesting to reflect on in this master's thesis as consumer goods like cosmetics are generally not a human need but a human-made capital. How can cosmetics then be ethical and sustainable? In fact, it is difficult to say how sustainably sourced cosmetic ingredients contribute to human needs such as community, freedom, and fulfilment. However, with right intentions and actions, wealth, health and other human made capital could contribute to human needs. Perhaps even more so in geographical areas where deficits in health and wealth are constraining factors to human needs.

In this discussion we would also like to take a step back and look at the final application, for what intended purpose this new sourcing scheme would be adopted. Is a cosmetic ingredient really the best application of indigenous species such as baobab and shea? That is a very hard question to answer but might be very important to ask in this stage. However, for the case of baobab, an application within the cosmetic industry would at least not compete with usage as food.

During the interviews and in general conversations around our master's thesis, we have noticed that people tend to refer to the process we call "caretaking and collection" in our PCO as the "bottom of the value chain" or the "end of the product chain". However, to us "caretaking and collection" is actually the start of the product chain.

During our work with this master's thesis, we have had our moments of doubt of the engineering-ness of the subject. We have realised that we had, and still have, a preconception on how an engineer works and what results an engineer should come up with. Our prejudices suggest that engineering should include calculations, programming and a final numerical answer, similar to how the number 42 answers the "*ultimate question of life, the universe and everything*" in the popular book "A Hitchhikers Guide to the Galaxy".

As you have probably noticed by now, our study does not provide such an answer but rather new questions. As engineers within the field of industrial ecology, we need to keep one foot in the field of technology and one foot in socio-ecological sciences. Therefore, we need to address and understand both the technology-nature and the technology-society relationship and impacts. For this purpose, the combination of study areas from feasibility and sustainability within the framework was a good match to give a general answer on how commercial activities can be combined with socio-ecological engagement. Yet, we have not provided an answer from our assessment framework either. We have not provided a "go" or "no-go" for any actor regarding the sourcing. Instead, we believe the questions presented in the assessment framework can make actors understand the challenges and opportunities related to sourcing of West-African seed oils as cosmetic ingredients.

9 Conclusion

The conclusion of this study is presented in three stages. Firstly, the research questions are revisited followed by a summary of the key insights, and the chapter is thereafter ended with a final comment.

9.1 Research Questions Revisited

What does the product chain organization (PCO) of a bio-based cosmetic ingredient look like?

The product flow starts with the caretaking of indigenous trees by local communities and ends with the production of a cosmetic ingredient by a B2B actor. In between, the process steps fruit processing, oil processing and fatty acid production are carried out. For each process step there are both direct and indirect actors that enable the product flow with different scope of action. The direct actors at the end of the product chain emphasize e.g., collaboration and partnerships as fundamental to their role. The direct actors at the start of the product chain understand local needs and availability of resources that can be integrated to the supply chain.

The partnership between certain actors can enable higher impact in identified areas such as market demand creation, local capacity building, collaborations, and policy advocacy, as well as regeneration and conservation of the trees. For example, the partnership between the local NGO and the SME creates a bridge between the local communities and the global market to create a balance between supply and demand. The indirect actors are also important to recognize as for example the local communities are directly dependent on the natural resources, while others like the consumers and B2C companies have a large impact on the demand which is important for the product chain.

How does the perspective on sustainable and ethical sourcing differ and align among the main actors of the product chain?

Sustainable sourcing is a complex topic that means different things to different actors. The collection and understanding of these actors' perspectives provide a comprehensive overview of what study areas to be addressed, understood, and respected when sourcing West-African seed-oils. It is evident that sustainability is not just a nice thing to have, but crucial to do business. All three dimensions of sustainability are addressed by the actors. To respect nature's carrying capacity and to contribute to the conservation and regeneration of the indigenous trees are two examples from the environmental dimension. To respect and safeguard traditional small-holdings and to empower women are two examples of perspectives from the social dimension. Within the economic dimension, most mentioned paying a fair price to collectors and fair value distribution along the product chain. The actors' perspectives on ethical sourcing tend to mainly focus on social aspects e.g., the respect of local structures, working conditions and especially fair pay and the distribution of value back to local communities supplying the raw material. However, what became evident was that paying a fair price is not enough to call something sustainably and ethically sourced. In fact, additional activities are necessary to ensure positive impacts on local communities and the conservation of trees.

What case specific study areas and criteria should be used to assess the sustainability and feasibility of baobab and shea when used as raw materials for cosmetic ingredients?

In total, 17 study areas and 38 criteria are formulated in an assessment framework. These study areas and criteria captures both feasibility and sustainability aspects relevant for the specific case of West-African indigenous seed-oils. These includes access and benefit sharing, facilities and capacity, environmental impact, and impact on local communities to mention a few examples. The criteria and overall assessment framework are by the authors of the study suggested to be used to:

1. **Define** to consumers, customers, and other stakeholders what the claim "sustainably and ethically sourced cosmetic ingredient" means.
2. **Assess** how many criteria that can be fulfilled today.
3. **Identify** activities and early partnerships needed to fulfil the criteria.
4. **Communicate** the complexity related to sustainable sourcing of indigenous West-African seed oils as feedstock for cosmetic ingredients.

The assessment framework should not be seen as a blueprint but rather as a guidance to understand what sustainable sourcing entails and clarify pathways forward.

According to these criteria, how can it be considered sustainable and feasible to source baobab and shea as raw materials for cosmetic ingredients?

This question requires more elaboration than a simple yes or no answer. It is more complex than that. Some criteria can be considered fulfilled, some require further information or research, and some are not fulfilled. Understanding of local context, transparency and traceability, and conservation of species are some criteria that are currently fulfilled. The price for final feedstock, sound health and safety procedures as well as available facilities and capacity are criteria that are not fulfilled or would require further studies. To engage in certain activities can ensure the fulfilment of most of the criteria that are currently not met. To ensure feasibility and sustainability, it is crucial to investigate the existing population of baobab trees, the final price of sustainably sourced baobab cosmetic oil and fatty acids, and oil processing options.

The sourcing of baobab as a raw material for cosmetic ingredients would utilize a by-product from an under-utilized resource that does not compete with food supply in the region. Furthermore, it would contribute to the conservation of the marvellous baobab trees as well as to improved livelihoods for local communities and women empowerment. However, investments in local oil processing facilities would be suggested to ensure that positive impacts and values are associated to the actors in the start of the product chain. Here, more technical expertise and training together with investments in machinery would be needed. Additional efforts and activities to ensure a sustainable sourcing would be to support research, policy, and regeneration of indigenous West-African species.

Currently, shea butter and shea based fatty acids are already available on the global market. To consider shea as sustainable and feasible alternative according to the assessment framework, it would require implementation in the sourcing platform already established for baobab. Evaluating alternative oil processing pathways for safe and high-quality production is an activity that would be required for integration of shea.

9.2 Key Insights and Final Comment

Lastly, the following list presents the key insights identified throughout the thesis work:

- Study areas and criteria can guide the assessment of feasible and sustainable sourcing but should not be considered as a blueprint.
- The enabling actors of the product flow stress the importance of local capacity building, market demand creation, policy advocacy, partnership, and collaboration as well as regeneration and conservation.
- The utilisation of baobab seeds brings value to a by-product of an already under-utilised indigenous tree and fruit that does not compete with local food supply.
- For baobab, oil yield highly impacts the applicability as industrial feedstock.
- The total West-African baobab tree population is currently a knowledge gap which makes scale up potential difficult to evaluate.
- There is a need to identify what sustainable and ethical sourcing actually means as the definitions vary among actors within a product chain.
- Sustainable and ethical sourcing are not just "nice to have" but fundamental to do business

Sustainable sourcing of baobab and shea could be a way to combine commercial activities with socio-ecological engagement. The sourcing could enable increased income to local communities, conservation of indigenous tree species, and the support of rural livelihoods. These three aspects have generally been highlighted as key for sustainable sourcing and have clear synergies among each other. The sourcing scheme suggested in this study is quite unusual, combining a large-scale specialty chemistry company, a small-scale food start-up, and a local NGO with very few middlemen. Some criteria are not perfectly met and would require further activities to be reached. Nonetheless, this is an opportunity to engage in an unconventional sourcing scheme with unconventional partnerships around unconventional seed-oils with potential to create a positive impact to both people and planet.

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Appendix A – Feasibility Framework Overview

Table: Overview of three different feasibility study frameworks (Behrens et al., 1991), (Goodman, 1988), (Ssegawa & Muzinda, 2021).

Framework	Study area	Information required
TELOS	Technical	Buildability, functionality/performance, reliability/availability, capacity, and maintainability
	Economic	CBA, breakeven, NPV, IRR or payback analysis
	Legal	Regulatory and ethical requirements (e.g., EIA, permits, etc)
	Operational	Environmental fitness (e.g., culture, structure, systems, policies, and stakeholder acceptance)
	Schedule	Possible completion within desired or mandatory time
UNIDO	Summary and background	Project promoter, background, location, objective and outline, economic and industrial policies supporting project
	Market analysis and marketing concept	Business environment, target market, market segmentation, competition, demand data, marketing strategies and costs, description of impacts on supplies, location, the environment, etc.
	Raw material and suppliers	Describe availability of raw materials, components, factory supplies, spare parts, supplies for social and external needs, summary of availability of critical inputs
	Location, site and environment	Ecological and environmental impact, socio-economic policies, incentives and constraints, infrastructural conditions and environment, critical aspects to justify choice of location
	Engineering and technology	Plant capacity, description of selected technology
	Organisation and overhead costs	Organizational design and management and measures required
	Human resources	Key persons, description of socio-economic and cultural environment, human resources availability, recruitment and training needs
	Project implementation schedule	Indication of duration of plant erection and installation, production start-up and running-in period, actions critical for timely implementation
	Financial analysis and investment appraisal	Total investment cost, cost of products sold, project financing, national economic evaluation, aspects of uncertainty, …
IPPMC	Technical	Site data (geology, soil conditions, drainage characteristics, climatic conditions, water supply, waste disposal, power, transportation), choice of available technologies (equipment and machinery, manufacturing process, spare parts), design (layout, engineering requirements, construction materials), manpower (professional, technical, labor)
	Economic	Demand (domestic, export), supply (domestic, export), marketing program, employment impact, raw material needs (domestic, import), costs and benefits
	Administrative/ Managerial	Internal organisation, external linkages, personnel and management
	Environmental	Physical/chemical (water, land, air, noise), ecological (species, population, habitats, communities, ecosystems), aesthetic (land, air, water, biota, man-made objects), social (individual well-being, social interactions, community well-being)
	Social/political	Social impact on culture and lifestyle, demography, political impact, equity, social justice, community resistance, institutional resistance, legal constraints, stability of political support
	Financial	Cash flow studies, profitability (external, domestic), source of funding and adequacy of funds

Appendix B – Nature's Contributions to People

Table: Nature's Contribution to People framework defined by IPBES (2019).

	Nature's contribution to people	**Indicator**
Regulating Contributions	1. Habitat creation and maintenance	• Extent of suitable habitat • Biodiversity intactness
	2. Pollination and dispersal of seeds and other propagules	• Pollinator diversity • Extent of natural habitat in agricultural areas
	3. Regulation of air quality	• Retention and prevented emissions of air pollutants by ecosystems
	4. Regulation of climate	• Prevented emissions and uptake of greenhouse gases by ecosystems
	5. Regulation of ocean acidification	• Capacity to sequester carbon by marine and terrestrial environments
	6. Regulation of freshwater quantity, location and timing	• Ecosystem impact on air-surface-ground water partitioning
	7. Regulation of freshwater and coastal water quality	• Extent of ecosystems that filter or add constituent components to water
	8. Formation, protection and decontamination of soils and sediments	• Soil organic carbon
	9. Regulation of hazards and extreme events	• Ability of ecosystems to absorb and buffer hazards
	10. Regulation of detrimental organisms and biological processes	• Extent of natural habitat in agricultural areas • Diversity of competent hosts of vector-borne diseases
Material Contributions	11. Energy	• Extent of agricultural land—potential land for bioenergy production • Extent of forested land
	12. Food and feed	• Extent of agricultural land—potential land for food and feed production • Abundance of marine fish stocks
	13. Materials and assistance	• Extent of agricultural land—potential land for material production • Extent of forested land
	14. Medicinal, biochemical, and genetic resources	• Fraction of species locally known and used medicinally • Phylogenetic diversity
Non-material Contributions	15. Learning and inspiration	• Number of people in close proximity to nature • Diversity of life from which to learn
	16. Physical and psychological experiences	• Area of natural and traditional landscapes and seascapes
	17. Supporting identities	• Stability of land use and land cover
	18. Maintenance of options	• Species' survival probability • Phylogenetic diversity

Appendix C – Description of Actors

Table: Description of Actors.

Name	Description	Meetings
Natalia Hinrichs-Tontrup	Head of Innovation Domain Sustainable Feedstocks at Evonik Industries AG. Supervisor of this master's thesis and probably a superwoman.	Weekly meetings and supervision
Andrew Hunt	Co-founder and CEO of Aduna with a mission to make baobab famous.	2 semi-structured interviews plus X meetings
Nick Salter	Co-founder and director of new product development at Aduna. Also on a mission to make baobab famous	2 semi-structured interviews plus X meetings
Peter Becker	Sustainability Manager at the Evonik business divison Care solutions of which Cosmetics is one business line. He has a long background of working in quality, procurement, and sustainability at Evonik Industries AG.	1 semi-structured interview + 1 meeting
Julius Awaregya	Director of the local NGO called ORGIIS that is operating in Paga, Ghana.	2 semi-structured interviews
Heike Pander	Educational background in social anthropology with a long record of development studies including land tenure, sustainable resource use, and participatory methods involving local communities (grassroots & regional level). Today, she is an independent journalist and a baobab expert that support the African Baobab Alliance with her expertise and perspectives.	1 semi-structured interview
Danièle Gelz	Working at the UN Convention for Combatting Desertification (UNCCD) with private sector and value chain issues. She is an expert in value chains with long experience of value chain creation and development from her previous role for UNDP in Central Asia.	2 semi-structured interviews
Aaron Adu	Managing director for the Global Shea Alliance (GSA), a non-profit industry association for all shea value chain stakeholders from small scale collectors to large scale industrial partners.	1 semi-structured interview
Julie Vallet	Part of the Corporate Sustainability team of L'Oreal working on Human Rights topics.	1 semi-structured interview
Jacques L'Haridon	Educational background and PhD in ecotoxicology. At L'Oreal he is responsible for the assessment of ingredients and formulas of products.	1 semi-structured interview
Eskil Mattson	Researcher, project manager, and expert on ecosystem services at IVL, the Swedish Environmental Research Institute. He has a PhD in Physical Geography and did his postdoctoral research at Chalmers University of Technology focusing on multi-functional land uses in the tropics in relation to climate policy, ecosystem services, and livelihoods.	1 semi-structured interview
Mathias Gustavsson	Senior researcher and consultant at IVL, the Swedish Environmental Research Institute as part of the international group where his work is focused on project development, impact assessments and methods for sustainability assessments. He has a PhD in Human Ecology from the University of Gothenburg and experience from the industry as energy system expert.	1 semi-structured interview
Oil consultants	Experts in oil extraction and oleochemical processes	1 semi-structured expert interview

Appendix D – Interview Guidelines

Short briefing on master's thesis and purpose of interview
The purpose of this thesis is to investigate how commercial activities can be combined with socio-ecological engagement when sourcing and integrating bio-based feedstock in an industrial supply chain.

The interview will be carried out in three main parts. To start with we will focus on you and your perspective on sustainable and ethical sourcing. The second section will focus on the interactions along the actors of the product chain. The third and final section will focus on more specific and detailed questions within your area of expertise.

Short introduction

- Could you tell us about yourself, your background and role at x?

Section 1: Actor Perspectives

- What does sustainable sourcing mean to you?
- What does ethical sourcing mean to you?
- Could you describe your role in the product chain?

Section 2: Actor Interactions

- Which actors within the product chain do you normally interact with in the product chain?
- What type of interactions do you have with these actors?

Section 3: Expert Knowledge

- A set of questions individual for each interviewee based on their area of expertise

Appendix E – Oil Processing Methods

Table: Overview of oil processing methods for shea.

Oil Processing Methods for shea	Traditional	Improved Traditional	Mechanical Cold Pressing	Solvent Extraction with n-hexane	Enzyme Extraction
Short Description	Traditional production method used to produce about 80% of Ghanaian shea butter. Main process steps are general pre-treatment (de-pulping, de-hulling, sorting, drying), pounding (size reduction), roasting (dehydration, milling to paste followed by kneading (breaking of oil cells), heating, oil separation and cooling	Improved traditional method tested in Gbimsi in Northern Ghana. Main process steps are General pre-treatment (de-pulping, de-hulling, sorting, drying), pounding (size reduction), roasting (dehydration), milling to paste followed by kneading with defined hot water, pressing in bridge press	Mechanical method using pressure to extract the oil form kernels or seeds. Main process steps are general pre-treatment (de-pulping, de-hulling, sorting, drying), heating, crushing/milling followed by a two-step pressing	A solvent (n-hexane) added to pulverized kernel enable the oil and fatty constituents to dissolve from kernel. Main process steps are general pre-treatment (de-pulping, de-hulling, sorting, drying), milling to paste followed by mixing, filtration and heating (to retain crude oil)	Enzyme extraction uses water-soluble enzymes to degrade the cell walls of release oil from kernel/see. Main process steps are general pre-treatment (de-pulping, de-hulling, sorting, drying), Roasting, milling to paste followed by enzymes added to seed paste for reaction, addition of boiling water, boiling of emulsion to separate oil
Yield [%]	25-40	67	30-45	40-66	47-74
Advantages	Final product applicable for cosmetic industry, using local knowledge known to women	Less firewood and water needed, extraction efficiency is improved, reduction in operational steps resulting in a less labour extensive process	Suitable from production of commercial quantities, higher productivity and less labour intensive, lower water use	COSMOS natural compliant, high yields	Increased yield, improved and high-quality vegetable oil, quality of residual meal, FFA value
Disadvantages	Low yield, uncontrolled processing which affect quality, firewood consumption, water consumption	Lower firewood consumption, lower water consumption	Expensive equipment, availability for women locally, maintenance, education need	COSMOS organic non-compliant, traces of solvent in final product, technically advanced, high related costs, not possible to adopt for local women	Import cost of enzymes high
References	Iddrisu et al (2019)	Iddrisu et al (2019)	Iddrisu et al (2019)	Iddrisu et al (2019)	Didia et al (2018)

Table: Overview of oil processing methods for baobab.

Oil Processing Methods for baobab	**Cold Pressing**	**Solvent Extraction**
Short Description	Mechanical pressing is the most common method for continuous treatment of oleaginous seeds. Industrial pressing of oilseeds is realised using continuous screw presses. The main process steps are washing, drying, crushing, sieving before pressed in a screw press one or two times	A solvent (n-hexane) added to pulverized seeds to enable the oil and fatty constituents to dissolve from seeds. Done for large quantities. The main process steps are washing, drying, crushing, sieving before mix with solvent in a solvent extraction facility. Some seeds need to be pre-pressed before the solvent extraction step.
Yield [%]	6.3-15	30
Advantages	Cold pressing preserves physiochemical properties, have no risk of solvent contamination, is relatively inexpensive after initial capital costs, no environmental concerns about the use of a screw press	Repeatable and reproducible results and process, high oil yields, relatively simple and easy, suitable for bulk oil extraction, allowed for COSMOS natural product label, decreased cost considerably if n-hexane can be recaptured and reused
Disadvantages	Can result in a yellow colour, low yield, be labour intensive, operators require semi-skill to attain the best outcomes, significant dependence on kernel treatment, i.e., moisture quantity, filtration or degumming process for oil is required	Costly if the hexane cannot be recovered, high hexane requirement, not allowed for COSMOS organic label, done for large quantities only, safety issues and environmental concerns
References	Cissé et al (2018) Wickens & Lowe (2004) Savoir et al (2013) Buhuiya et al (2020) Personal communication with oil consultants, April 30th 2021	Cissé et al (2018) Buhuiya et al (2020) Personal communication with oil consultants, April 30th 2021

References Appendix E

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Appendix F – Material Flow Analysis

For baobab, the data in the table below was used as a basis for the MFA.

Table: Data for MFA.

Data point	Symbol	Data	Unit	Source
Yield of baobab fruits per tree	F_{low}	30	kg	(Wickens & Lowe, 2008)
	F_{high}	120	kg	Data provided by Aduna
Seeds in baobab fruit	X_{low}	30	%	Data provided by Aduna
	X_{medium}	43	%	(Wickens & Lowe, 2008)
	X_{high}	60	%	(Wickens & Lowe, 2008)
Pulp in baobab fruit	P	15	%	**Data provided by Aduna**
Shell and Fibre in baobab fruit	SF	55	%	Data provided by Aduna
Oil content in seeds	O_{low}	13.0	%	(Lykke et al., 2021)
	O_{high}	22.7	%	(Lykke et al., 2021)
Baobab oil yield cold pressing	Y_{low}	6.2	%	(Cissé et al., 2018)
	Y_{medium}	11	%	(Wickens & Lowe, 2008)
	Y_{high}	15	%	(Wickens & Lowe, 2008)
Fatty acid	FA	80	%	Assumption based on the theoretical ideal case that provides 90% fatty acids from input oil.
Evonik demand of fatty acids based on bio-based raw materials	D_{Evonik}	50-100	tonnes	Provided by Evonik
Aduna's annual yield of baobab fruits	$S_{Fruits,Aduna}$	~1000	tonnes	Provided by Aduna.

Some data varies quite substantially e.g., oil yield from cold pressing, oil content of seeds, and the percentage of seeds in fruits. Therefore, both an upper case and a lower case for material flows were calculated. To calculate the potential supply of baobab oil (S_{Oil}) based on Aduna's current annual supply of baobab fruits, the following equation was used

$$S_{Oil,i} = S_{Fruits,Aduna} * X_i * Y_i \text{ (tonnes)}$$

where the index i=high, medium, low. To also evaluate the potential supply of fatty acids, the following equation was used.

$$S_{Fatty\ Acid,i} = S_{Oil,i} * FA \text{ (tonnes)}$$

where the index i=high, medium, low. The material flows could then be calculated, and the two cases of a high and low supply are presented. The different scenarios are presented below.

Table: MFA scenarios for cosmetic oil and fatty acid output.

Scenario	Oil (tonnes)	Fatty acids (tonnes)
Low Seed High Yield	45	36
Low Seed Medium Yield	36	28.8
Low Seed Low Yield	18.6	14.9
Medium Seed High Yield	64.5	51.6
Medium Seed Medium Yield	51.6	41.3
Medium Seed Low Yield	26.7	21.3
High Seed High Yield	90	72

To calculate how many fruits that would be needed to supply the fatty acid demand (D_{Evonik}), the following equation was used.

$$S_{Fruits,i} = \frac{D_{Evonik,j}}{FA * Y_i * X_i} \quad \text{(tonnes)}$$

where the index i=high, medium, low and the index j= high, low. To instead calculate how many fruits that would be needed to supply the demand (D_{Evonik}) if the oil is of interest, the following equation was used

$$S_{Fruits,i} = \frac{D_{Evonik,j}}{Y_i * X_i} \quad \text{(number of trees)}$$

Based on the equations, the demand of 50 tonnes of baobab based fatty acids or baobab oil would require 694-3360 and 556-2688 baobab fruits respectively. For the demand of 100 tonnes of baobab based fatty acids or baobab oil, 1389-6720 and 1111-5376 tonnes of baobab fruit respectively. Similar to the previous results, the oil yield and seed ratio assumptions affect the final tonnage.

The required fruit supply can be used to calculate the required amount of trees by the following equation

$$S_{Trees,i} = \frac{S_{fruit,i}}{F_{high}} \quad \text{(amount of trees)}$$

Here, F_{low} is not used as Aduna discarded the figure as inadequate based on their own operational findings. Depending on all factors that affect the required amounts of fruit needed, the required number of trees needed to supply Evonik's demand of baobab based cosmetic ingredients spans between 4630-6720 trees.

Sensitivity Analysis

As can be seen from the scenario table, an increase of three percentages on the oil yield parameter increases the final yield of baobab oil and fatty acids by nine tonnes and seven tonnes respectively, for the same seed ratio. In other words, one percent increase of yield can increase oil yield by three times. For changes in the seed parameter, the correlation is instead 1.5 tonnes increased oil yield per percentage of seed ratio increased.

References Appendix F

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Appendix G – Actor Perspectives

Table: Actor perspectives on sustainable and ethical sourcing collected from interviews.

Role	What does sustainable sourcing mean to you?	What does ethical sourcing mean to you?
Global B2B Specialty Chemical Company	• Sustainable sourcing within company can differ • Don't make any harm with what we are doing • Risk and opportunity management • Apply internal global policies, commitments and initiatives • Take part in external collaborative initiatives • Falls under responsible sourcing • It is a customer demand • Sustainability is not a standard and should not be a standard	• Profit sharing along the supply chain • Fair trade • Approach towards suppliers • Add value to people outside working market • Give incentives to customers to develop their operations • Not exclude other actors from a recourse
SME	• Traditionally more focus on environmental aspects e.g., monocultures, permaculture, and biodiversity • For wild harvest crops, it includes aspects around conservation agriculture, propagation and harvesting techniques • The co-existence of environmental and community sustainability • Existential question, basic survival and the ability to generate income, livelihood, education • Not CSR • Preservation of local values in the long term • Connection to a sustainable market	• Not a sub-category or "nice-to-have" • Basis for all businesses • Ethical traditional and outdated, can be changed to transparency • Transparency around fair pay, impact on livelihoods • A gut-feeling, knowing that a business has integrity and is sharing your values
International Organization	• Living the agenda 2030 and implementing SDGs • Consideration of soil quality and land degradation • Minimize negative impacts on land by humanity related activities • Environmental, social and economic aspects addressed • Environmental aspects include climate change mitigation and adaptation, biodiversity, soil and land use • The active engagement in the question of how we can make the economic system more sustainable?	• UN SDG number 10, reducing inequalities • Value creation and value going to the local population • Fairtrade
Researcher and Sustainability Assessment Expert	• Going beyond law and regulations • A goal and ambition that companies and societies can work towards, not a steady state • Work in the highest degree possible towards the Agenda 2030 and its defined goals • To integrate all aspects and not include/neglect aspects of the Agenda 2030	• Paying a fair amount of a products worth • Paying a fair amount to all actors in the supply chain, especially in the start of the value chain • Protecting and conserving existing smallholdings, ownership structures of land and land use • Safeguarding and preservation of ecosystem services

Researcher and Ecosystem Expert	• Environmental sustainability is a basis • Keep a life cycle perspective, meaning consider all steps in value chain when developing a product • Set the right demands and requirements to suppliers	• Social aspects of sustainability e.g., labour rights, salaries, and the documentation for these structures
Baobab Expert	• To only extract so much form the environment that it can regenerate itself • Sustainable sourcing should go along with ethical sourcing	• To assess if and how the local community benefit from selling the product • Understand the local ownership and tenure structures • Create local work opportunities when harvesting local resources
Local NGO	• Economic, social, environmental benefits to direct producers • A balance between profit for companies and social and environmental impact • A market dedicated to sustainability • Sustainable sourcing is not a written document, but something that needs to be continuously followed, reviewed and measured • It is difficult to achieve sustainable sourcing • To not over-exploit resources, to stay within the nature's carrying capacity • To make sure local producers are paid properly • Safeguard agroforestry systems	• More related to a social driven agenda but very linked with sustainable sourcing • Ethical has to do with transparency and accountability • Placing value on each human being on earth, whatever colour or race you find yourself
Global B2C Cosmetic Manufacturer	• Economic empowerment through fair pat and relationship to e.g., farmers • Decent and safe working conditions for farmers and collectors • Equality between workers • Preservation of biodiversity • Action on climate change (deforestation, emissions, ...)	• Collaborative support and development in risk areas instead of avoidance to empower SMEs • Work collaborative and in partnership • Fair pay and wages
Industry Organisation for Shea	• Empower women • Protect natural resources and more specifically shea parklands • Develop women cooperatives • Provide business development services for women cooperatives • Enable capacity building for women cooperatives • Engage in Health and Safety activities • Research how to reduce wood and water use in shea butter production	• To not take advantages of the women who produce shea • Ensure women get their fair share of the final price • Reduce influence and income of middlemen

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