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Top 10 Business Models for Productive Use in Sub-Saharan Africa

An Analysis of the Countries Namibia, Rwanda, Senegal, and Uganda

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Abstract

While 14 % of the world's working-age population currently lives in sub-Saharan Africa (SSA), this figure will predictably be higher than the rest of the world combined by 2036. If this demographic group finds meaningful employment, Africa will experience an economic and social upswing. To tap this potential, the thesis intends to answer the research question, *"What are the prerequisites and how are they defined for the successful implementation of sustainable business model ideas in SSA?"*, by developing a top ten ranking consisting of previously identified sustainable business model ideas best suited for productive use. This realizes a novel approach to implementing future-oriented business models and contributes to current research on sustainable models. Since the geographical scope of SSA is pervasive, this thesis focuses on Namibia, Rwanda, Senegal, and Uganda. An extensive literature review on these countries provides a more comprehensive understanding of the situation in SSA. Additionally, research conducted on the agricultural, energy, and information and communications technology (ICT) sectors allows to identify the most promising ideas. Moreover, interviews with professionals and analysis of panel discussions improve current knowledge. The work combines the Business Model Canvas (BMC) with the circular economy concept, serving as a framework for the business model ideas. Experts evaluated these ideas, which were subsequently ranked using fuzzy logic with artificial intelligence, based on the system for exploring country risks (CRISK-Explorer). The thesis shows that skipping individual development processes opens up promising opportunities, such as the ICT-based business model *e-crowd logistics* or the renewable energy-based model *e-Boda-Boda*. Seven prerequisites for the successful implementation of these ideas were identified and defined: value delivery, promising customers, sufficient capital, the presence of key resources, the possibility to perform the key activities, sustainability, and profitability. The thesis concludes by identifying limitations and suggesting avenues for future research.

Keywords: Sub-Saharan Africa; Sustainable Business Model Canvas; Leapfrogging; Sustainable Agriculture; Renewable Energy; ICT; Fuzzy Logic

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List of abbreviations and acronyms

Abbreviation/Acronym	Explanation
AFFORD	African Foundation for Development
AUDA-NEPAD	African Union Development Agency - New Partnership for Africa´s Development
BMC	Business Model Canvas
CBD	Cannabidiol
E-commerce	Electronic commerce
E-waste	Electronic waste
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
HBV	Hepatitis B virus
ICT	Information and Communications Technology
kWh	Kilowatt-hour
LED	Light-emitting diode
mAh	Milliampere hour
PHL	Post-harvest losses
RAS	Recirculating Aquaculture Systems
Re-commerce	Re-use-e-commerce
SDG	Sustainable Development Goals
SSA	Sub-Saharan Africa
UGX	Ugandan Shilling
UIA	Uganda Investment Authority
USAID	United States Agency for International Development

Glossary

Since most of the terms used in this master thesis are subject-specific, it is necessary to explain and clarify some of them for a comprehensive understanding:

- **Cash crops**: A crop grown primarily for sale rather than for use by the people who grew it or the residents of the area where it is grown.[1]
- **Circular economy:** A circular economy is designed for reuse from the outset and aims to ensure that products, components as well as materials always retain their maximum utility and value. Thus, new opportunities for innovation across several fields are created.[2] In doing so, waste is to be avoided as far as possible. Wherever feasible, durable products are leased, rented, or shared.[3]
- **DC motor**: A DC (direct current) motor is an electrical machine that converts electrical energy into mechanical energy by generating a magnetic field that is powered by direct current.[4]
- **E-commerce:** Business conducted via the Internet.[5]
- **Last-mile delivery:** Last-mile delivery refers to the activities required for physical delivery to the final destination chosen by the recipient. The last mile refers to the physical transfer of a material or product from the source to the final destination, for instance, from the supply side to the demand side.[6]
- **Leapfrogging:** The omission of individual stages in a development process.[7]
- **Organoleptic characteristics**: Organoleptic characteristics are the aspects of food or other substances as perceived by the senses, including smell, taste, touch, and sight, in cases where moisture, dryness, and stale-fresh factors are to be considered.[8]

[1] Cf. Cambridge University Press, ‘Cash crop’.

[2] Cf Webster, 'Circular economy', p. 17.

[3] Cf. Münger, 'Kreislaufwirtschaft', p. 28–31.

[4] Cf. IQS Directory, ‘DC motor’.

[5] Cf. Oxford University Press, ‘E-commerce’.

[6] Cf. Alharbi et al., ‘Crowd Models’, p. 2.

[7] Cf. Bogner and Hertzberg, ‘Afrikanischer Traum’, p. 26.

[8] Cf. Educalingo, ‘Organoleptic characteristics’.

- **Post-harvest losses (PHL):** Quality and quantity losses in food production from harvest to consumption.[9]
- **Subsistence agriculture/farming**: Subsistence agriculture/farming is an agriculture or farming system that provides all or nearly all the needs of the farm family, usually without significant surpluses that can be sold.[10]
- **Sustainability**: Sustainable action ensures that the needs of the present are met without compromising the ability of future generations to meet their own needs.[11]
- **Telematics**: Telematics is a method of monitoring vehicles, equipment, and other assets by using GPS technology and on-board diagnostics to plot the movements on a computerized map.[12]
- **Voice search:** Voice search is a speech recognition technology that allows users to say search terms out loud instead of typing them into a search box.[13]

[9] Cf. World Economic Forum, 'Opportunities for circular economy', p. 15.

[10] Cf. Merriam-Webster, 'Subsistence agriculture/farming'.

[11] Cf. Sommer, 'Green business models', p. 24.

[12] Cf. Geotab Team, 'Telematics'.

[13] Cf. TechTarget Contributor, 'Voice search'.

1 Introduction

"Our people need jobs. Our people need role models. Our people need to see that you don't need to migrate out of Africa to earn a living or to earn a decent life."[14] – Tony Elumelu

Over the past two decades, sub-Saharan Africa (SSA) has witnessed strong economic growth.[15] In the process, Africa is leapfrogging[16] – the absence of retail chains could, for instance, lead to a surge in electronic commerce (e-commerce[17]).[18] Nevertheless, this hitherto economic growth has predominantly been jobless and characterized by inequality and poverty. More than half of the population in SSA is still engaged in the low-productivity agricultural sector. Although women constitute about half of the agricultural labor force (47 %), there is great inequality. It has been found that if women had access to the same resources as men, agricultural yields would increase by up to 30 %, and at the same time, the number of hungry people would decrease by 100 million to 150 million worldwide.[19]

The extreme speed at which the continent is catching up decades and developing is related to other significant increases. In addition to substantial population growth and urbanization, there is a notable surge in energy demand. Between 2000 and 2012, energy demand in SSA grew about 45 %, with a continuing upward trend.[20] West Africa alone is forecast to see a 100 % rise in regional electricity consumption by 2030. Though, this would be accompanied by an estimated 102 % increase in carbon emissions.[21] Moreover, the young population and the working-age population are forecast to expand.[22] While 14 % of the world's working-age population currently lives in SSA, this figure will predictably be higher than the rest of the world combined by 2036. If this demographic group finds meaningful employment, Africa could

[14] Praise, 'Quote'.

[15] Cf. Shimeles et al., 'Agriculture in Sub-Saharan Africa', p. 1.

[16] See Glossary.

[17] See Glossary.

[18] Cf. Bogner and Hertzberg, 'Afrikanischer Traum', p. 26.

[19] Cf. Shimeles et al., 'Agriculture in Sub-Saharan Africa', p. 1-2.

[20] Ibid., p. 97-98.

[21] Cf. The World Bank Group, 'Power of energy'.

[22] Cf. The World Bank Group, 'Demographic Boom'.

experience an economic and social upswing; if not, they will most likely migrate out of the continent.[23] The Nigerian economist and philanthropist, Tony Elumelu, has already recognized this, saying that Africans need jobs and role models, and they need to be able to see that you don't have to migrate out of the continent to make a living or live a decent life.[24] Hence, African challenges must be addressed, and the untapped potential and opportunities in SSA must be exploited to increase economic growth for the benefit of the population. One way to do this is by developing and successfully implementing sustainable business model ideas, which will be highlighted in this thesis.

The thesis is structured as follows. The introductory chapter provides a historical overview and a first outline of the current situation in SSA. Furthermore, the research question is derived, the aims, assumptions, and delimitations of this thesis are stated, and the applied method is presented. The first half of the second chapter presents a conceptualization of an extended framework for sustainable business models - the Business Model Canvas (BMC) with an integrated aspect of the circular economy (chapter 2.3). For this purpose, literature on the traditional BMC is reviewed first, as well as on the circular economy[25] (chapter 2.1 – 2.2). In the second half, a review of recent literature on four selected countries – Namibia, Rwanda, Senegal, and Uganda – is presented (chapter 2.4), followed by a review of promising fields for sustainable business model ideas best suited for productive use (chapter 2.5 - 2-7). In the third chapter, based on the previously gained insights from the literature review, ten promising ideas for sustainable business models are identified, inserted into the circular BMC framework, and evaluated. Chapter four presents the results of these evaluated ideas in the form of a top ten ranking, followed by a discussion (chapter five). Chapter six provides the conclusion, including limitations and suggestions for further research.

[23] Cf. Bogner and Hertzberg, ‘Afrikanischer Traum’, p. 24.

[24] Cf. Praise, ‘Quote’.

[25] See Glossary.

1.1 Research question and aims

As mentioned above, one way to address Africa's challenges and to capitalize on the potential and opportunities in SSA is to develop and successfully implement sustainable business models. Therefore, the overall purpose of this master thesis is to answer the central question of *"What are the prerequisites and how are they defined for the successful implementation of sustainable business model ideas in SSA*?*"* by creating and discussing a top ten ranking of sustainable business model ideas best suited for productive use. Since SSA is geographically vast, this thesis focuses on the countries Namibia, Rwanda, Senegal, and Uganda.

The research question leads to several related sub-questions that need to be answered to deliver comprehensive work on the issue. First, are all identified prerequisites equally easy to fulfill? And second, are all developed business model ideas equally promising for productive use in SSA?

To answer these questions, several aims are set. The main aim is to closely declare which prerequisites entrepreneurs need to consider for the successful implementation of sustainable business model ideas. This main aim is broken down into smaller aims: demonstrating in a reasoned manner whether all prerequisites are equally easy/difficult to meet and whether some ideas are more promising for some of the countries studied. Furthermore, this thesis aims to generate up-to-date data from the pre-existing real-life cases, by participating in webinars.

Although there is sufficient literature on traditional BMC by Osterwalder and Pigneur[26], the circular economy (e.g., addressed by Münger[27]), and the SSA realities depicted by several research papers and organizations such as the World Bank Group, the literature review did not provide information on ranked sustainable business model ideas for productive use in SSA. Filling this gap is another aim of this thesis.

Notably, the thesis provides a unique value added to the existing theoretical research by extending the traditional BMC with the concept of the circular economy and developing a circular BMC framework as well as applying it directly.

The exact procedure to answer the research question and its related sub-questions as well as to achieve the set aims is explained in the Methodology chapter (chapter 1.3).

[26] Cf. Osterwalder and Pigneur, 'Business Model Generation'.

[27] Cf. Münger, 'Kreislaufwirtschaft'.

1.2 Assumptions and delimitations

For simplicity reasons and to limit the scope of this work, the following assumptions and delimitations are made:

- The term “entrepreneur” conveys male, female as well as diverse persons. If a specific gender is referred to, the term is supplemented by the addition of "male/female".
- Concerning the circular economy, the distinction between cycles (inner cycle, extended cycle, cross-industry cycle, and pure cycle) is not taken into account.
- As far as infrastructure is concerned, traffic and transport, telecommunications and energy are considered, while, for instance, rail and maritime transport are not considered.
- Since this thesis focuses on economic aspects, chapter 2.5 presents the scientific background in a simplified way.
- To limit the scope and keep the focus on circularity, only the coupled aquaponic system is considered and the decoupled system is not considered (compare chapter 2.5.1).
- No distinction is made in the use of the terms cannabis and hemp, even if there is a difference in the natural sciences.
- The fuzzy logic used to perform the ranking will not be discussed further in this thesis, as this is outside the scope of the research.

1.3 Methodology

An extensive literature review was conducted on the countries Namibia, Rwanda, Senegal, and Uganda, as well as on the agricultural, energy, and information and communications technology (ICT) sectors to identify the most promising business ideas best suited for productive use. By combining the underlying BMC with circular economy aspects, a framework for the ideas was designed.

Moreover, professionals with various backgrounds were interviewed during webinars, as well as panel discussions analyzed, supplemented by subsequent exchanges, to obtain further information on the business model ideas. Including grey literature was essential, allowing practical examples to be demonstrated.

Experts (PhD student conducting research in the African context and representatives of the Africa Institute) eventually evaluated the business model ideas based on thirteen criteria:

1) Access (difficulty and limitation) to required resources,
2) Amount of capital required (less/lot),
3) Benefit for the economy,
4) Benefits for end consumers,
5) Benefit for the environment,
6) Benefit for society,
7) The complexity of technology,
8) Coverage of circular economy aspects,
9) External restrictions (e.g., legal),
10) The necessity of the business idea for the market,
11) Need for know-how,
12) Profitability (qualitative reasoning),
13) Use of energy from renewable sources.

The ranking of the ideas was performed using fuzzy logic (see "Fuzzy-Logik: Einführung in die algebraischen und logischen Grundlagen" (Böhme, 1993)) with artificial intelligence, based on the system for exploring country risks (CRISK-

Explorer) for larger and smaller emerging market countries proposed by Steurer in "Quantitative Country Risk Assessment".[28]
The experts' rating was converted into a score value between zero and 100 according to the following formula:

$Total\_Score(n) = \sum_{i=1}^{13} w_i f(x_i)$.[29]

Whereas zero corresponds to the lowest attractiveness and 100 to the highest attractiveness. *N* denotes a business model idea *n*, x_i an attractiveness indicator (*i*= 1…13), w_i the weight for the attractiveness indicator *i*, and $f(x_i)$ the transformed value of factor *i*.[30]

[28] Cf. Böhme, 'Fuzzy logic'; Steurer, 'Risk Assessment'.

[29] Cf. Steurer, 'Risk Assessment', p. 9.

[30] Cf. ibid.

2 State of the science

As mentioned in the first chapter, this second chapter provides an overview of the current state of science and primarily serves as a basis for the development of the business model ideas as well as for the implementation of the ideas in the circular BMC framework.

For this purpose, the first part creates the understanding for the development of promising sustainable business ideas with the help of the mapped circular BMC framework and presents its components. Subsequently, a brief overview of SSA, in general, is given and the conditions, potentials, but also problems of the four sub-Saharan countries are discussed. Lastly, certain opportunities for creating productive use in SSA are reflected.

2.1 Business Model Canvas

The BMC developed by Alexander Osterwalder and Yves Pigneur has become a standard format that can be used in many industries to describe business models in a comprehensible way. On the one hand, its presentation in the form of a visual chart divided into nine basic building blocks (see Figure 1, next page) provides transparency for an actual analysis of the current business model, and on the other hand, it forms a comprehensible starting point for validation, discussion, adaption, and development as well as for a selection of possible future business models.[31]

Osterwalder and Pigneur define a business model as a model which describes the basic principle of how an organization creates, delivers, and captures value.[32] The nine basic building blocks cover the four main fields: financial viability, offer, customers and infrastructure.[33] The following section takes a closer look at these nine blocks.

[31] Cf. Ematinger, 'Geschäftsmodell 4.0', p. 21-22.

[32] Cf. Schallmo, 'Geschäftsmodelle', p. 15.

[33] Cf. Osterwalder and Pigneur, 'Business Model Generation', p. 15.

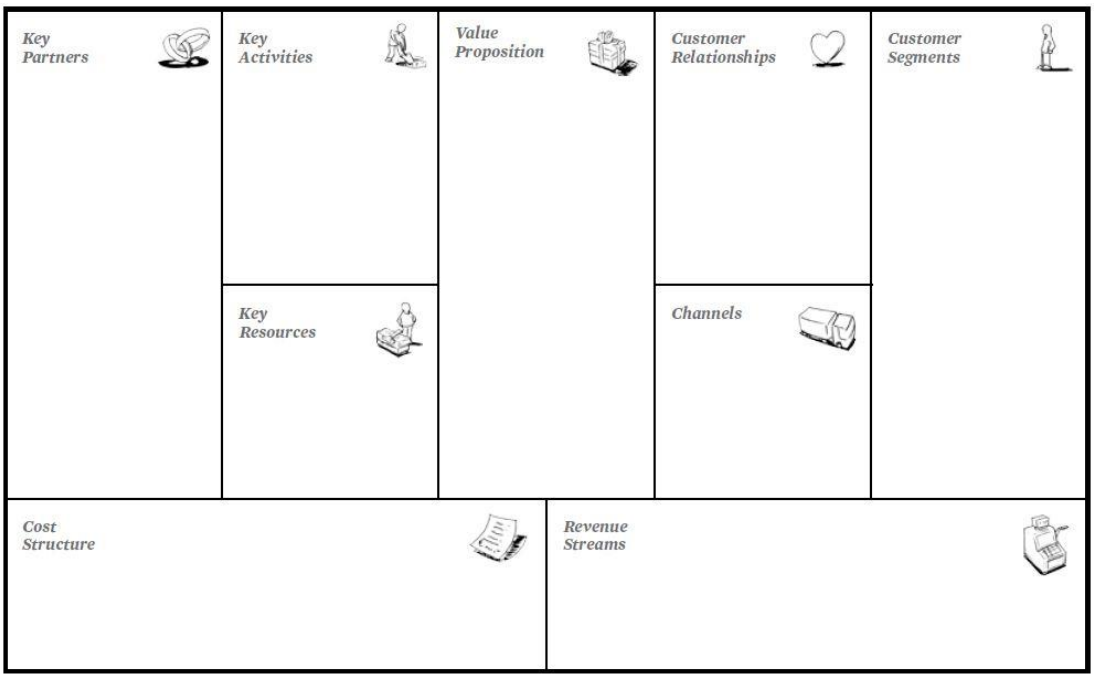

Figure 1 Business Model Canvas[34]

At the center of the model, there is the **value proposition building block**. This block describes the benefit of products and services for a specifically defined customer segment. Values can be of qualitative nature (for instance design, customer experience, or satisfaction) as well as of quantitative nature, like costs, speed of service, and life cycle. Due to these value propositions, customers' needs and wants are satisfied and problems are solved.[35]

The **customer segments building block** represents the key to success because without (profitable) customers, every company will run out of business. To increase the success of the company, customers need to be grouped into specific segments, with common characteristics and needs, that a company wants to serve. The next step is to decide which segments have priority and which may be ignored. To determine this, the following questions must be answered: for who is the company creating value, and who are the most important customers for the company?[36]

Considering the **customer relationships building block**, this block answers the following questions: What type of relationship is expected to be established and maintained by each of the company's customer segments? How costly will they be and

[34] Ibid., p. 44.

[35] Cf. ibid., p. 22-25.

[36] Cf. ibid., p. 20-21.

how can they be integrated with the rest of the business model? Relationships can range from automated to personal and can be driven by motivations like customer acquisition, customer retention, or upselling. For instance, automated services can recognize individual customers and their characteristics and provide information about their orders.[37]

Through which channels do the customer segments of the company want to be reached and which channel works best? – This question arises at the **channels building block**, which covers the transaction structure of the business model. It describes in which way the value propositions are delivered to the customers. These channels have five distinct phases (see Figure 2). However, not every phase needs to be covered at each channel. In general, you can distinguish between owned and partner channels, as well as between direct channels and indirect channels. Owned channels can be both, direct and indirect. An example of an owned direct channel is an in-house sales force or a website, whereas owned or operated retail stores by an organization are examples of indirect channels. The key to success in delivering a value proposition to the chosen segment is finding the right channel type or the right mix of these channel types.[38]

Figure 2 Channel phases[39]

The cash that the company generates from each customer segment is represented by the **revenue stream´s building block**. For what value are the customers willing to pay and how would they prefer to pay? Plus, what is the share of each revenue stream in total revenue? These questions are addressed in this building block. Successful answers allow the company to generate one or more revenue streams from each customer segment. There are several ways to generate these streams, such as through

[37] Cf. ibid., p. 28-29.

[38] Cf. ibid., p. 26-27.

[39] AltexSoft, ‘Channel phases’.

asset sales, usage, and subscription fees or leasing/renting, licensing as well as advertising.[40]

Coming to the building block that comprises the resource structure and describes the most important assets required for the business model to work – the **key resources building block**. Here, the question is: what are the key resources needed to make the business model work? These resources can be physical, financial, intellectual, or human, which are crucial in knowledge-intensive and creative industries. Key partners may own, lease, or acquire them, depending on the nature of the business model.

Compared to the key resources building block, the **key activities building block** covers the transaction structure (like the channels building block) and describes the most important actions a company must take to operate successfully. Here the question is, which key activities are needed for the value proposition, the channels, the customer relationships as well as for the revenue streams?[41]

To cope with uncertain times, efficient networks of suppliers and partners may be decisive. Such networks that make the business model work are described by the **key partnerships building block**. Therefore, the question of who are the most important partners must be answered.[42]

Apart from all the facts mentioned above, a business model without considering the **cost structure** would not be sustainable. The ninth building block, therefore, describes all costs (fixed costs, variable costs), that occurred by use of the other eight blocks. To address this block, one should ask: what are the most important costs inherent in the business model? And which resources and activities are the most expensive? Considering business model cost structures, it can be distinguished between two broad classes: cost-driven, focusing on minimizing costs wherever possible, and value-driven, focusing on value creation due to a high degree of personalized service.[43]

In conclusion, the BMC is easy to implement with little effort, and the intuitive structure requires no training. In addition, the coherence is easy to observe. The visual approach, as well as the recognition of connections also speaks in favor of the Canvas. Nevertheless, it is often criticized because the BMC is very superficial. It only covers

[40] Cf. Osterwalder and Pigneur, 'Business Model Generation', p. 30-33.

[41] Cf. ibid., p. 34-37.

[42] Cf. ibid., p. 38-39.

[43] Cf. ibid., p. 40-41.

a certain point in time and specific important aspects, such as competition or trends, are not covered.[44] For instance, current trends, such as the one towards sustainability[45]. However, taking this trend into account would be particularly important, as it is claimed that sustainability is 'the driver for innovation'.[46]

Therefore, the following chapter will now take a closer look at one point of sustainability – the circular economy.

[44] Cf. Becker and Brücker, 'Vor- und Nachteile', p. 3–5.

[45] See Glossary.

[46] Cf. Sommer, 'Green business models', p. 167.

2.2 Circular economy as a strategy for the future

The quest for improved resource efficiency or even efforts to counteract climate change indicates that a rethinking towards more sustainability is taking place.[47] The development of sustainable business models is thus becoming increasingly important, for many reasons. By introducing sustainable business models, for example, new sustainable jobs can be created, GDP growth can be promoted, resources can be used more sparingly, and environmental impacts can be reduced.[48]

The following section will now explain why the concept of the circular economy and rather the concept of "Design Circular" can serve as a promising strategy for the future, showing that the circular economy plays a central role in understanding where prosperity might come from in an ever-changing world.

A. Münger defines Design Circular as a regenerative circular economy, whereby the three pillars of sustainability (economic pillar, ecological pillar, and social pillar) are extended by the component of technology. Technology is often crucial for the successful implementation of the circular economy in society.[49] Through Design Circular, resource depletion can be identified as well as new opportunities to reduce it can be revealed. Products are now optimized for the future rather than for quantity.[50] Author K. Webster speaks here of "design for life".[51]

By applying Design Circular, existing business models are reviewed and redefined into new sustainable business models, thus, the product life cycle is extended through maintenance, redistribution, repair, refurbishment, and/or local/regional reprocessing cycles.[52] This redefinition can also be called a business model innovation, as it represents an innovation of individual elements, the combination of elements, or even the entire business model, thus meeting unsatisfied, hidden, or new customer needs.[53]

[47] Cf. Münger, 'Kreislaufwirtschaft', p. 15.

[48] Cf. Colombo et al., 'Circular business models', p. 386.

[49] Cf. Münger, 'Kreislaufwirtschaft', p. 15.

[50] Cf. Webster, 'Circular economy', p. 15, 20.

[51] Cf. ibid., p. 47.

[52] Cf. Münger, 'Kreislaufwirtschaft', p. 35–40.

[53] Cf. Schallmo, 'Geschäftsmodelle', p. 20-23.

As a result of applying Design Circular, companies will achieve higher productivity and better profitability in the medium to long term. Additionally, as a positive side effect, new sustainable jobs are created.[54]

In the best-case scenario, products in the circular economy have "no" life cycles. At the end of its life, the product is returned to another cycle and reused there. This means less waste, resulting in lower energy consumption, which in turn adds value to the ecosystem.[55] Colombo et al. refer to this as a closing loop strategy. Here, for example, waste is transformed into new raw materials to manufacture new products. The narrowing loop strategy focuses on the reduction of resources, for instance, through the use of renewable sources. In the slowing loop strategy, the focus is on extending the life of products, through repair, maintenance, remanufacturing, and reuse. In addition, the intensifying loop strategy emphasizes the importance of a more intensive use phase, this strategy refers for example to the sharing economy where manufacturers act as service providers and customers are no longer considered as product owners but as users. And lastly, the dematerializing strategy includes ICT-based business models in which companies receive revenue, for example, through subscription contracts for services.[56]

After this first section, it is now clear what is meant by Design Circular and what it is good for. But how can one define a product or service that perfectly fits this circular concept? For this purpose, the “7 Rs” of the circular economy were developed:

- ✓ **Reduce:** the aim here is to save raw materials wherever possible. If it makes sense, they are replaced by alternative, more sustainable materials;
- ✓ **Re-use:** in this process, companies develop ideas on how products that have already been manufactured, or at least many components, can be used again or in a different way;
- ✓ **Repair:** already in the design phase of a product, it is important to consider repair possibilities;
- ✓ **Re-fit:** in particular, products with a high purchase value should undergo a so-called "refit”, but such overhauling could also benefit inexpensive products;

[54] Cf. Webster, 'Circular economy', p. 24–40.

[55] Cf. Münger, 'Kreislaufwirtschaft', p. 77.

[56] Cf. Colombo et al., ‘Circular business models’, p. 388-389.

- ✓ **Re-build:** this involves the rebuilding or technological upgrading of products;
- ✓ **Re-furbish:** products that have reached the end of their life cycle are rebuilt or put to a different use (upcycling);
- ✓ **Re-cycle:** recycling products is still better than disposing of them permanently, even if this often results in material losses.[57]

At the end of this section, it becomes apparent that a smart solution for businesses is the consideration of the circular economy as a strategy for the future, which entails a wide variety of potential opportunities for economic value creation. The following chapter will demonstrate what a sustainable business model with an integrated aspect of the circular economy can look like.

[57] Cf. Münger, 'Kreislaufwirtschaft', p. 40-44.

2.3 Circular Business Model Canvas

As mentioned before, the development of sustainable business models is becoming increasingly essential to improve resource efficiency. Therefore, the within this thesis identified sustainable business model ideas are based on the BMC by Osterwalder and Pigneur (compare chapter 2.1) and integrate a circular economy aspect, as proposed by Münger (compare chapter 2.2). Figure 3 represents the extended framework of these business model ideas. The questions in italics are from the traditional BMC, while the remaining questions relate to the circular economy. In addition to these questions, it can be asked whether the company exercises a circular strategy (e.g. closing loop or narrowing loop strategy).

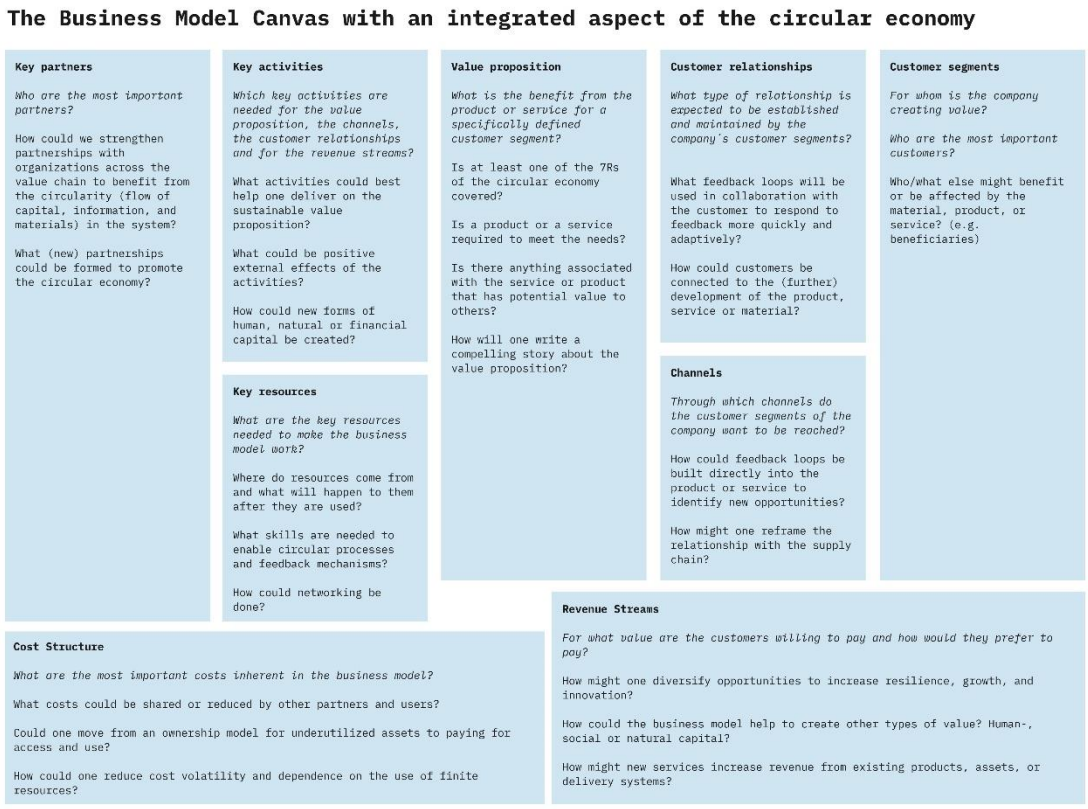

Figure 3 Circular Business Model Canvas[58]

[58] Own illustration, based on Osterwalder and Pigneur, 'Business Model Generation', p. 44; Münger, 'Kreislaufwirtschaft', p. 126-132.

2.4 Sub-Saharan Africa

Now that the framework for the sustainable business model ideas to be identified has been developed, the following section first provides a broad overview of SSA and then examines the four selected African countries in more detail to gain a broader understanding of the situation in SSA, as well as the promising fields for sustainable business model ideas, to later use the information gained to fill out the circular BMC framework.

As the name suggests, SSA is geographically the sub-Saharan part of the African continent (compare Figure 4, highlighted purple) and includes 49 states.[59] The largest area of uncultivated farmland worldwide is found in SSA. However, this uncultivated land holds untapped potential for many people, as more than half of the population (54 %) is employed in agriculture.[60]

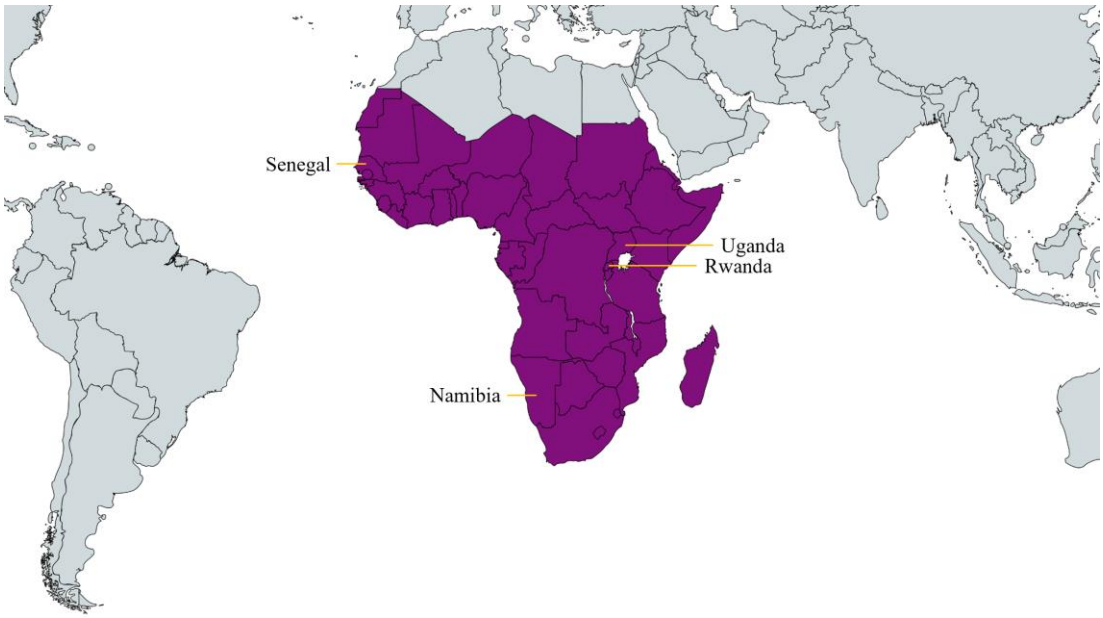

Figure 4 Sub-Saharan Africa[61]

To date, agriculture in SSA is mainly rain-fed and based on subsistence farming[62]. Currently, about 95 % of food and feed is produced through rain-fed agriculture,

[59] Cf. Bogner and Hertzberg, 'Afrikanischer Traum', p. 21.

[60] Cf. Shimeles et al., 'Agriculture in Sub-Saharan Africa', p. 1-2, 181.

[61] Following IndustriALL, 'SSA'.

[62] See Glossary.

potentially leading to food insecurity and malnutrition since 60 to 90 million hectares of land will be affected by intense drought by 2060.[63]

One reason for the dependence on rain-fed agriculture is low agricultural productivity. On the one hand, low productivity is due to poor rural infrastructure and outdated or inadequate transportation, and on the other hand, due to production-related constraints. Furthermore, most smallholders still rely on rudimentary production techniques.[64]

Poor rural infrastructure and outdated or inadequate transportation to connect primarily rural producers to markets have the greatest negative impact on PHL[65].[66] In SSA, PHL account for 30 % to 50 % of production and thus have a strong influence on productivity.[67] Often, a lack of refrigeration on the way from farmer to market is to blame for crops spoiling. In fact, 45 % of food in developing countries spoils, primarily due to a lack of cold storage.[68] The ambient temperature in SSA can rise to 45 °C.[69] Minimizing PHL increases food supply and thereby reduces food security concerns. Through a 2015 study of PHL in SSA, it was found that the volume of food losses over ten years exceeded the value of total food aid received. Therefore, urgent action is required, and solutions need to be created on the ground.[70]

In addition to empowering women (in the agricultural sector), modernizing agriculture by focusing on sustainable techniques are priorities to move away from subsistence farming, address food insecurity and increase agricultural productivity. Another challenge for SSA is responding and adapting to the impacts of climate change. For example, farmers should provide alternative farming methods for otherwise rain-fed crops to safeguard harvests and address drought exacerbated by climate change. Increasing agricultural productivity would enable farmers to better manage and, most importantly, integrate the entire agricultural value chain (from farm to processing, storage, transportation, marketing, etc.). As a positive side effect, new jobs would also

[63] Cf. Shimeles et al., 'Agriculture in Sub-Saharan Africa', p. 181; Obirikorang et al., 'Improved food security', p. 7.

[64] Cf. Shimeles et al., 'Agriculture in Sub-Saharan Africa', p. 16, 181.

[65] See Glossary.

[66] Cf. World Economic Forum, 'Opportunities for circular economy', p. 15.

[67] Cf. ibid., p. 15, 19.

[68] Cf. ColdHubs, 'Solar-powered cold storage'.

[69] Cf. Sakiliba and Hassan, 'Solar PV powered cooling', p. 1.

[70] Cf. World Economic Forum, 'Opportunities for circular economy', p. 15, 19.

be created. In addition, they could take advantage of large markets and gradually integrate regional and, above all, global value chains. Moreover, the development and promotion of the agricultural sector could be used as a catalyst for industrialization.[71]

2.4.1 Namibia

The circumstances of the country Namibia provide the framework in which new, sustainable, and circular business models can be implemented. There are several factors, such as demography, climatology, agriculture, as well as the infrastructure and the business environment, that strongly influence the implementation. In the following, a brief overview of the country is given followed by an analysis of these factors. The analysis ends with a summary that reflects the key findings that are crucial to the development of the business model ideas. This procedure also applies to the other three countries below.

Country overview

Namibia is the driest country in SSA, with a total surface area of 825,418 square kilometers.[72] 92 % of its total land area is defined as semi-arid, arid, or very-arid. Only 2 % is arable and 46 % is perennial natural pasture.[73] Windhoek, located in the center, is the capital and the largest city in the country.[74]

Thanks to its natural wealth of mineral resources and relatively small population, Namibia is a stable upper-middle-income country. In 2020, the gross domestic product (GDP) per capita (purchasing power parity (PPP)) was 9,298.1 USD.[75]

However, Namibia struggles with various development problems. These include bad quality of education and high unemployment, resulting in unequal distribution of income.[76] Most of the poor population lives in rural areas, without adequate access to basic services. Even though the poverty rate has declined in recent years, job creation continues to stagnate, and extreme socioeconomic inequalities persist, reinforced by

[71] Cf. Shimeles et al., 'Agriculture in Sub-Saharan Africa', p. 7-56, 285-287.

[72] Cf. The World Bank Group, 'Country profile Namibia', p. 2 .

[73] Cf. ibid., p. 5, 17.

[74] Cf. South African History Online, 'Windhoek'.

[75] Cf. The World Bank Group, 'GDP (PPP)'.

[76] Cf. GIZ, 'Namibia'.

the COVID-19 pandemic. Furthermore, only slightly more than half (55.2 %) of Namibia's population had access to electricity in 2019, with the rural population estimated to account for less than 10 %.[77] Other serious challenges facing the country include pollution, especially in large urban areas, and water scarcity.[78]

Demography

Namibia is two and a half times the size of Germany but is home to only about 2.54 million people (2020)[79]. There is hardly any other country in the world where the gap between rich and poor is as wide as in Namibia.[80] Due to its size and small population, the country is extremely sparsely populated, only three people can be found per square kilometer. Today, 50 % of the population is located in urban areas. Urbanization is expected to increase, with 61 % of the population living in urban areas by 2030 and 72 % by 2050.[81] Currently, the other half of the population lives in rural areas.[82]

About 70 % of Namibia´s population depends directly or indirectly on agriculture as its main source of income, and one-third of the labor force is employed on farms.[83] Most of the poor live in rural areas and extreme inequalities exist. It was noted that the high poverty levels and social as well as economic disparity are due to the lack of employment opportunities. In 2016, more than one-third of the population was unemployed. Women, young people, and people living in rural areas were particularly affected.[84] In 2020, Namibia had a labor force of 930,694 people (an increasing trend).[85]

The Namibian population is increasingly threatened by vector-borne diseases due to climate change. People in rural areas are likely to be most at risk, as they often have difficult access to medical facilities. In the future, the number of epidemics could increase, as well as smaller and larger disease outbreaks that place additional demands

[77] Cf. The World Bank Group, ‘Country profile Namibia’, p. 2-3, 25.

[78] Cf. ibid., p. 16,21.

[79] Cf. KfW, ‘Namibia’; The World Bank Group, ‘Population Namibia’.

[80] Cf. KfW, ‘Namibia’.

[81] Cf. The World Bank Group, ‘Country profile Namibia’, p. 2–3.

[82] Cf. ibid., p. 2-3, 17.

[83] Cf. GIZ, ‘Rural livelihoods Namibia’.

[84] Cf. The World Bank Group, ‘Country profile Namibia’, p. 2-3, 17.

[85] Cf. The World Bank Group, ‘Labor force’.

on the current health infrastructure. Therefore, it is very important to adapt the Namibian health system and strengthen its resilience. For example, communication and transportation systems need to be strengthened.[86]

Climatology

The average total annual precipitation of Namibia is only 269.2 mm.[87] The average annual temperature of Namibia is 20.6 °C.[88] In recent years, warming in Namibia has been higher than the global average. According to analysis, temperatures across the country are expected to increase by 1.7 °C to 5.4 °C by the 2080s.[89]
Climate change will negatively impact crop and livestock production. The nature of climate change impacts on Namibia's fisheries is highly uncertain.[90]

Agriculture and natural resources

The agricultural sector contributes just about 7 % to 10 % to Namibia´s GDP but is critical to the economy and overall food security. Despite its small contribution to the GDP, agriculture is the main user of water, consuming about 75 % of all water.[91]
Namibia´s dependence on rain-fed agriculture increases its vulnerability to climate change.[92] Especially in communal areas, agricultural production is still largely characterized by subsistence farming with heavy dependence on rainfall, low crop yields, and limited access to water.[93] Water is an important but scarce resource in Namibia. It is estimated that only 2% of precipitation ends up as surface run-off and only 1 % becomes available to recharge Namibia´s groundwater, with the remaining 97 % lost to evaporation.[94]
Namibia´s fish resources, not only on the coast but also inland, are of great importance and make it one of the countries with the most productive marine fishing grounds

[86] Cf. The World Bank Group, 'Country profile Namibia', p. 27-30.

[87] Cf. The World Bank Group, 'Namibia Climatology'.

[88] Cf. ibid.

[89] Cf. The World Bank Group, 'Country profile Namibia', p. 8-11.

[90] Cf. ibid., p. 18-19.

[91] Cf. ibid., p. 17.

[92] Cf. ibid., p. 3.

[93] Cf. GIZ, 'Rural livelihoods Namibia'.

[94] Cf. The World Bank Group, 'Country profile Namibia', p. 21.

worldwide.[95] More than 20 essential fish species are landed using a variety of fishing methods. The commercial fishing and fish processing industries contribute remarkably to the economy in terms of export earnings, jobs, and contribution to Namibia´s GDP.[96]

According to estimates, GDP could decline by 6.5 % per year because of climate change. To maintain productivity in the future and counteract the decline in GDP, the focus should be on drought-resistant and early maturing crop varieties (climate-adaptive farming practices) as well as the improvement and strengthening of water resource management, like recycling wastewater, etc.[97] In short, the agri-food sector needs to be made more resilient.[98]

Infrastructure

A good infrastructure is indispensable for the coexistence and functioning of a society, both in the private and business context. Poor infrastructure can prevent companies from implementing their business model. Therefore, it is of immense importance to analyze the existing infrastructure, take the circumstances into account, and incorporate them into the business model when developing the business idea. In the following, the points traffic and transport, telecommunication as well as energy will be discussed in more detail.

Traffic and transport

The transport sector is particularly important for the Namibian economy, as it provides access to markets, services, and jobs on the one hand and execution of business logistics on the other.

In general, Namibia has a well-developed road network, of which the most important routes are tarred.[99] However, Namibia´s transport system can still be further improved and expanded, in particular in the poorer and slightly more densely populated north to boost sustainable development and improve access to markets, services and jobs.[100]

[95] Cf. ibid., p. 17.

[96] Cf. ibid., p. 19.

[97] Cf. ibid., p. 4, 20, 25.

[98] Cf. GIZ, ‘Rural livelihoods Namibia’.

[99] Cf. Namibian Government Portal, ‘Infrastructure Namibia’.

[100] Cf. KfW, ‘Namibia’.

The country has set itself the goal of becoming a leading regional distribution and logistics country by 2030.[101]

Telecommunication

Namibia is one of the countries that are developing ICT very quickly.[102] In recent years, the country has invested heavily in modernizing and expanding its telecommunications. In 2020, 41 % of the country´s population was using the Internet (an increasing trend).[103]
According to the Harvard Africa Competitiveness Report 2000-2001, the quality of telecommunications services in Namibia was ranked as the best in Africa.[104]

Energy

Hydroelectric power, petroleum, imported coal, and imported electricity are the country's main sources of energy. Unfortunately, Namibia's resources do not cover even one-third of its energy needs. More than 50 % of its electricity is imported from neighboring Zimbabwe, Zambia, and South Africa, as well as from the Southern African Power Pool.[105] However, Namibia has great potential for generating its electricity from solar and hydropower, wind, and biomass. The country has committed to improving its energy situation by increasing the share of renewable energy in electricity generation from 33 % in 2010 to around 70 % in 2030.[106]
In chapter 2.6 "Productive use through energy", possibilities are shown on how to use this potential of solar energy.

Business environment

Namibia´s labor market consists of a highly developed formal sector on the one hand and a large, relatively unproductive subsistence agriculture sector on the other. This

[101] Cf. GIZ, 'Improving mobility'.

[102] Cf. 'Infrastructure'.

[103] Cf. The World Bank Group, 'Internet usage'.

[104] Cf. Namibian Government Portal, 'Infrastructure Namibia'.

[105] Cf. The World Bank Group, 'Country profile Namibia', p. 25.

[106] Cf. ibid., p. 25-26.

duality, combined with the low productivity of the primary sector and slow job creation, leads to very high unemployment in the country.[107]
Namibia´s most important trading partner is South Africa.[108]
The tourism sector is one of the fastest-growing sectors in Namibia. In 2014, tourism contributed 14.2 % to the country´s GDP.[109]

At the end of the first country analysis, the following key findings can be compiled, which will later serve as a foundation for the development of the top ten business model ideas:

- 👎 high dependency on rain-fed agriculture,
- 👎 high unemployment (with more women than men),
- 👎 great inequalities between women and men,
- 👎 increasing threat from vector-borne diseases,
- 👎 lack of/limited access to electricity (especially in rural areas),
- 👎 water scarcity (agriculture as the main user of water),
- 👎 rising temperatures,

- ☞ most people employed in the agricultural sector,
- ☞ increasing urbanization,
- ☞ the tourism sector is one of the fastest growing sectors,

- 👍 well-developed road network (most important routes are tarred),
- 👍 aiming to be a leading regional distribution and logistics country by 2030,
- 👍 quick ICT development,
- 👍 high potential of significant energy resources (e.g. solar),
- 👍 one of the countries with the most productive marine fishing grounds worldwide.

[107] Cf. The World Bank Group, 'Country diagnostic', p. 17.

[108] Cf. GIZ, 'Economy Namibia'.

[109] Cf. The World Bank Group, 'Country profile Namibia', p. 30-32.

Thus, the country's potential lies in the following areas:

- sustainable (climate-smart) agriculture,
- renewable energy,
- ICT,
- logistics,
- fisheries,
- tourism.

2.4.2 Rwanda

Rwanda is growing and is the darling of investors as well as a pioneer of digitalization. Many entrepreneurs see the future of Africa in the Rwandan model. At least before the pandemic.[110] In the following section, this Rwandan model will be explained in more detail.

Country overview

Rwanda is a small landlocked country in central Africa. Kigali is the capital of the country and is located approximately in the center of the country. The total surface area is 26,338 square kilometers, of which about 30 % is covered by forests, 15 % is wetland and 52 % is arable. The total cultivated area is equivalent to 66 % of the national territory, with over 93,000 hectares of swamp under cultivation.[111]
In Rwanda, the most important cash crops[112] are tea and coffee.[113] As many small, cultivated areas are located on hills or in mountainous regions, increased runoff and landslides occur, raising the country´s vulnerability to the effects of climate change.[114] Despite being a low-income country, Rwanda ranks as one of the top 30 places worldwide to do business and is one of the fastest-growing economies in Africa. In 2020, the GDP per capita (PPP) was 2,213.8 USD.[115] Rwanda´s Vision 2050, a plan

[110] Cf. Bogner and Hertzberg, 'Afrikanischer Traum', p. 22-24.

[111] Cf. The World Bank Group, 'Country profile Rwanda', p. 2, 18, 20.

[112] See Glossary.

[113] Cf. The World Bank Group, 'Country profile Rwanda', p. 16.

[114] Cf. ibid., p. 2.

[115] Cf. The World Bank Group, 'GDP (PPP)'.

to transform the country into a middle-income country by 2035 and a high-income country by 2050, requires an average GDP growth rate of at least 12 % per year, in the period from 2018 to 2035, and of at least 10 % in the period from 2035 to 2050. However, the annual growth rate was 9.5 % in 2019 and -3.4 % in 2020. The decline can be attributed to the COVID-19 pandemic. The pandemic has resulted in unprecedented negative social as well as economic impacts.[116]

Demography

Rwanda is home to one of the highest population densities in the world: 525.02 persons per square kilometer (2020).[117] As of 2020, the population includes 12.9 million people, with an annual growth rate of 2.5 %.[118] Approximately 17.4 % of the 12.9 million people live in urban areas. This percentage is projected to increase to 20 % in 2030, and to 26.9 % in 2050. The urbanization can be seen as both a challenge and an opportunity for the country.

Strong economic growth significantly improved Rwandan living standards. The focus on development-oriented initiatives and policies has led to improved access to services. However, only 37.8 % of Rwanda´s population had access to electricity in 2019.[119]

In 2020, Rwanda had a labor force of 6,440,635 people (an increasing trend).[120] More than 70 % of the employed population is engaged in the agricultural sector, which is vulnerable to climate change, and of these, nearly 90 % of households engage in subsistence agriculture.[121] Research has shown that women and children are more often affected by climate-related disasters than men. And gender differences in access to credits and assets or treatment by formal institutions are among the key factors responsible for women´s and men´s differential vulnerability.[122]

Like the Namibian population, the Rwandan population is increasingly threatened by vector-borne diseases due to climate change. The ability to respond quickly,

[116] Cf. The World Bank Group, ‘Country profile Rwanda’, p. 2, 5.

[117] Cf. The World Bank Group, ‘Population density’.

[118] Cf. The World Bank Group, ‘Country profile Rwanda’, p. 2–3.

[119] Cf ibid.

[120] Cf. The World Bank Group, ‘Labor force’.

[121] Cf. The World Bank Group, ‘Country profile Rwanda’, p. 15.

[122] Cf. ibid.

effectively, and appropriately to potential climate-related hazards is critical to the success and resilience of Rwanda's health sector.[123]

Climatology

The country´s tropical climate is characterized by an average annual temperature of 19.1 °C.[124] Temperatures are expected to continue to rise.[125] Rainfalls vary widely across Rwanda; the average total annual precipitation is 1,177.7 mm.[126]
In particular, the likelihood of droughts is increasing in eastern and central regions. As a result of rising temperatures and increasingly frequent droughts, water resources will be severely stressed.[127]

Agriculture and natural resources

As mentioned at the beginning of this chapter, approximately 52 % of Rwanda's land area is arable. About 73 % of this is used for growing crops such as food crops, cash crops, and fodder. The remaining 27 % is either used for grazing, reforestation or is fallow.[128] Like other sub-Saharan countries, Rwanda is highly dependent on rain-fed agriculture, which is mostly practiced by smallholder farmers.[129]
Rising temperatures threaten highly lucrative but temperature-sensitive crops such as coffee and tea, which are the most important cash crops and account for more than 20 % of export revenues.[130] Another important resource found in Rwanda is fresh water. However, this resource is, like the others, also threatened by climate change, increasing urbanization, and industrial expansion. In the future, options for irrigation infrastructure must be given greater consideration to secure the important resource of water in all regions.[131]

[123] Cf. ibid., p. 24-26.

[124] Cf. The World Bank Group, ‘Rwanda Climatology’.

[125] Cf. ibid.

[126] Cf. The World Bank Group, ‘Country profile Rwanda’, p. 6.

[127] Cf. ibid., p. 12-13.

[128] Cf. ibid., p. 15.

[129] Cf. ibid., p. 5.

[130] Cf. ibid., p. 3–16.

[131] Cf. ibid., p. 18.

Changes in precipitation are also very likely to harm rice cultivation. Therefore, investments, for instance, in irrigated agriculture and crop as well as export market diversification and sustainable innovation, like climate-smart and land-efficient techniques, in the agricultural sector are of utmost importance to increase productivity and ensure food security and revenues.[132]

Under Rwanda´s Vision 2050, the agricultural sector aims to be market-oriented and linked to urbanization as well as trade. Productivity is to be increased by a factor of fifteen compared to today. To achieve this, agricultural value added per worker must more than increase eightfold by 2035 and more than triple by 2050. However, the availability of electricity and water must be significantly increased since the availability is still very limited today.[133]

Traffic and transport

For the successful realization of Vision 2050, infrastructure must be further developed. This includes, on the one hand, a modern and efficient transport system, with public transport serving more than 90 % of the population, and, on the other hand, a formal housing sector that is accessible to all segments of the population.[134]

To reduce transport costs for both individuals and businesses, Rwanda is investing in road, rail, and water transport infrastructure. Almost one-tenth of the annual budget is spent on transport and other infrastructure.[135]

Rwanda's vision for the transport sub-sector is to become the most important logistics hub for East and Central Africa due to its geographical location.[136] However, its transport sector is the main contributor to urban air pollution, and as the largest urban center and also the main center for transport management services, the problem is most pronounced in the capital city of Kigali.[137] Fortunately, in recent years, the transport sector has improved significantly, and environmentally friendly transport is promoted.[138]

[132] Cf. ibid., p. 3–16.

[133] Cf. ibid., p. 15-16.

[134] Cf. ibid., p. 27.

[135] Cf. Rwanda Development Board, ‘Infrastructure Rwanda’.

[136] Cf. Republic of Rwanda, ‘Infrastructure report’, p. 1.

[137] Cf. SSATP, ‘Mobility Rwanda’, p. 13-14.

[138] Cf. Republic of Rwanda, ‘Infrastructure report’, p. 2, 7.

Regarding passenger transportation, it is negatively noted that the current public transportation is insufficient to meet peak demand. The motorcycle cab is a popular mode of transportation in Rwanda, especially in rural areas.[139]

Telecommunication

The country has set itself the goal of becoming a center for ICT capacity building at the highest level. To this end, the government has already invested in ICT infrastructure.[140] A 7,000km nationwide fiber network as well as a 4G LTE network covering 95 % of Rwanda provide instant connectivity throughout the country.[141] Rwanda is already a well-known tech hub on the African continent.[142]
In 2020, 27 % of the country´s population was using the Internet (an increasing trend).[143] Digital transformation of the country is crucial for a robust post-pandemic recovery.[144] For instance, in Rwanda, e-commerce is relatively new and not widespread so far. However, online trade is expected to grow further. The market volume of e-commerce in Rwanda in 2022 is 408 million USD and is forecast to almost double to 728 million USD in 2025.[145] To exploit and develop this potential, chapter 2.7 – Productive use through ICT – shows, among other things, how productive use can be created by innovative e-commerce-business models.

Energy

One of the lowest electricity consumption rates per capita in the central-east African region is found in Rwanda. Fortunately, electricity generation increases significantly.[146] In fact, Rwanda has doubled its power generation capacity in the last ten years.[147] Households account for the largest share of electricity consumers, followed by the industrial sector, which uses energy mainly for motor drivers and

[139] Cf. SSATP, 'Mobility Rwanda', p. 39, 76.

[140] Cf. Rwanda Development Board, 'ICT Rwanda'.

[141] Cf. Rwanda Development Board, 'Tourism b'.

[142] Cf. Karanja, 'Tech hub'.

[143] Cf. The World Bank Group, 'Internet usage'.

[144] Cf. The World Bank Group, 'Digital Transformation'.

[145] Cf. Bogner and Hertzberg, 'Woman', p. 108, 110.

[146] Cf. The World Bank Group, 'Country profile Rwanda', p. 22-24.

[147] Cf. KfW, 'Rwanda'.

lighting.[148] More than 80 % of Rwanda's population relies on wood fuels to meet their energy needs, making the country highly vulnerable to climate change.[149] However, the country has a variety of potentially significant energy resources, including solar, geothermal, wind, and hydropower.[150]

Business environment

As already mentioned, Rwanda ranks as one of the top 30 places worldwide to do business and is one of the fastest-growing economies in Africa. More precisely, according to the World Bank, the country is ranked as the second easiest place to do business in Africa and the second fastest growing economy on the continent. It has free trade agreements with over 50 countries. Moreover, designated land is available for the development of small and large businesses, as is reliable, high-quality infrastructure, competitive tax, and non-tax regulations as well as streamlined administrative procedures.[151] Tax incentives include, for example, the existence of a 15 % preferential corporate income tax for strategic sectors such as ICT, energy, and transport.[152]

The rapidly growing tourism sector is the largest source of foreign exchange earnings in the country. In 2019, revenues from this sector amounted to 498 million USD.[153]

Another important sector that can drive economic growth is the real estate sector. In 2019, the sector grew by 4 %. The country needs 5.5 million housing units by 2050, equivalent to 150,000 housing units per year. At least 415,000 housing units must be built by 2032, of which approximately 70 % must be for low- and moderate-income communities.[154]

[148] Cf. The World Bank Group, 'Country profile Rwanda', p. 22-24.

[149] Cf. ibid.

[150] Cf. Republic of Rwanda, 'Infrastructure report', p. 16.

[151] Cf. Rwanda Development Board, 'Visit Rwanda'.

[152] Cf. Rwanda Development Board, 'Opportunities'.

[153] Cf. Rwanda Development Board, 'Tourism a'.

[154] Cf. Rwanda Development Board, 'Real estates'.

At the end of the analysis, the following key findings can be compiled that are crucial to the development of the business model ideas:

- high dependency on rain-fed agriculture (mostly practiced by small-holder farmers),
- great inequalities between women and men,
- lack of/limited access to electricity (one of the lowest electricity consumption rates per capita in the central-east African region),
- rising temperatures,
- frequent droughts,
- water scarcity,

- most people employed in the agricultural sector,
- second fastest growing economy in Africa,
- increasing urbanization (expectation 26.9 % by 2050),
- households account for the largest share of electricity consumers,
- tea and coffee as the most important cash crops,

- one of the top 30 places worldwide to do business,
- pioneer of digitization,
- high-quality infrastructure,
- increasing electricity generation,
- high potential of significant energy resources (e.g. solar),
- aiming to be a center for ICT capacity building at the highest level.
- promotion of environmentally friendly transport,
- tourism sector as one of the fastest-growing sectors and the largest contributor to foreign exchange,
- promising real estate sector.

Thus, the country's potential lies in the following areas:

- sustainable (climate-smart) agriculture,
- renewable energy,
- ICT,
- logistics,

- tourism,
- real estate and construction.

2.4.3 Senegal

Sarah Diouf, one of Africa's most successful fashion designers and the most famous fabric designer in Senegal, believes Africa will be the next big thing. The only question, she says, is who will benefit.[155] To uncover Senegal's potential to benefit its citizens, also this country will be analyzed.

Country overview

Senegal is located in the westernmost part of the African continent.[156] The country´s total surface area is 196,710.00 square kilometers.[157] The capital city, Dakar, is the westernmost African city on the North Atlantic Ocean.[158]

Senegal is one of the politically most stable countries in Africa and is a lower-middle-income country.[159] In 2020, the country´s GDP per capita (PPP) was 3,502.8 USD (2020).[160] Its economy is driven by the service sector, which was the main driver of Senegal´s GDP growth between 2014 and 2018 and remains the main contributor to the country´s GDP. Currently, agriculture is the most dynamic engine of growth.[161] It employs three-quarters of Senegal's workforce, and family farms account for 95 % of activity. The main crops grown in the country are groundnuts and cereals (millet, rice, sorghum, peanuts, cassava, black-eyed peas, and cotton sugar cane).[162]

Despite the strong economic performance, the population´s standard of living remains very low. Poverty is most prevalent in rural areas, where about 60 % of the population lives.[163]

[155] Cf. Bogner and Hertzberg, 'Zeit', p. 23.

[156] Cf. The World Bank Group, 'Senegal Country summary'.

[157] Cf. The World Bank Group, 'Surface Senegal'.

[158] Cf. The World Bank Group, 'Country profile Senegal', p. 1, 7.

[159] Cf. Lindsay-Herrera, 'Risk profile Senegal', p. 1; The World Bank Group, 'Senegal Overview'.

[160] Cf. The World Bank Group, 'GDP (PPP)'.

[161] Cf. The World Bank Group, 'Senegal Overview'.

[162] Cf. The World Bank Group, 'Country profile Senegal', p. 9.

[163] Cf. ibid., p. 2.

Like other sub-Saharan countries, the country is vulnerable to the impacts of climate change. Senegal is threatened by droughts, bushfires, floods, locust invasions as well as sea level rise, and coastal erosion. Sea level rise particularly affects economic activities such as agriculture, fisheries, and tourism.[164]

In addition, increasing urbanization can be expected in the future, which can also lead to problems if no jobs are available for the urban population.[165]

Currently, 80 % of the population is younger than 35 and youth unemployment is high. But there is also a lack of jobs for the older generation.[166]

To gradually put the economy back on track and manage urbanization, several challenges need to be addressed, including strengthening agricultural productivity and competitiveness, improving water management as well as lowering energy costs, and reducing the carbon footprint. In addition, sustainable jobs must be created.[167]

Demography

Senegal´s inhabitants represent a highly educated and skilled workforce.[168] In 2020, Senegal had a labor force of 4,258,114 people with an increasing trend (a total of 16.7 million people live in the country (2020)).[169] With an annual population growth rate of 2.7 % in 2020, there has been a slight decline since 2015.[170]

The impact and risks of vector-borne and waterborne diseases are also increasing in Senegal due to climate change. Dakar and other urban areas, already prone to flooding, are particularly at risk from an increase in cholera outbreaks.[171]

Although agriculture contributes only around 17 % to the country´s GDP, it remains the main source of income for most Senegalese. Most of them make their living primarily from small-scale agriculture.[172]

[164] Cf. ibid., p. 5-8.

[165] Cf. ibid.

[166] Cf. Bogner and Hertzberg, 'Zeit', p. 26-27.

[167] Cf. The World Bank Group, 'Senegal Overview'.

[168] Cf. Ndiaye, 'Senegal update', p. 2.

[169] Cf. The World Bank Group, 'Labor force'.

[170] Cf. The World Bank Group, 'Population growth Senegal'.

[171] Cf. Lindsay-Herrera, 'Risk profile Senegal', p. 4.

[172] Cf. The World Bank Group, 'Country profile Senegal', p. 5-9.

Climatology

Senegal´s tropical climate is characterized by two different seasons: a rainy season from June to September and a dry season from about October to May. The dry areas of the country (predominantly the upper half of the country) receive less than 300 mm of precipitation per year, while the forested south receives an average of 1,200 mm per year. However, precipitation varies greatly both year-to-year and decade-to-decade.[173] In general, a decrease in total precipitation has been observed in recent years.[174] Furthermore, mean annual temperatures are projected to increase by 1.1°C to 3.1 °C by 2060 and by 1.7 °C to 4.9 °C by 2090.[175]

Agriculture and natural resources

Senegal is rich in water reserves. More than 93 % of the urban and 67 % of the rural population have adequate access to water.[176] Over 90 % of water resources are consumed by agriculture.[177] However, the nation´s water sector is expected to be among the sectors most vulnerable to climate change impacts.[178] The consequences of climate change may affect the availability and degraded quality of freshwater resources. It will also lead to reduced hydropower production, which contributes about 10 % to the country´s electricity supply.[179]

As mentioned before, the main crops grown are groundnuts and cereals. However, groundnuts are sensitive to higher temperatures and fluctuating precipitation. Yields are forecast to decline by 5 % to 25 % in the future.[180]

Due to its insufficient productivity in the agricultural sector, Senegal imports about 60 % of its cereal needs, in particular rice. Unfortunately, in many regions, its soils have lost valuable organic matter and fertility has deteriorated. To increase productivity, several adjustments must be made, including product diversification, use

[173] Cf. The World Bank Group, ‘Senegal Climatology’.

[174] Cf. ibid.

[175] Cf. The World Bank Group, ‘Country profile Senegal’, p. 4-5.

[176] Cf. Lindsay-Herrera, ‘Risk profile Senegal’, p. 2.

[177] Cf. ibid.

[178] Cf. The World Bank Group, ‘Country profile Senegal’, p. 11.

[179] Cf. Lindsay-Herrera, ‘Risk profile Senegal’, p. 1-2.

[180] Cf. ibid., p. 3.

of varieties with short cycles and tolerance to salinity, reorganization of farming systems, dissemination of agroforestry techniques, collection, and water storage.[181]
While agriculture is the main source of income for most Senegalese, fishing is the second largest source of income and employment.[182] Aquaculture is one of the pillars of Senegal's development strategy for sustainable growth. The production of tiger shrimp, tilapia, or feeding fry is among the investment opportunities.[183] Though, fish stocks are declining because of overfishing. Additionally, the fisheries sector is also facing major challenges due to climate change as water temperatures change and mangrove losses are projected.[184]

Traffic and transport

The country´s transport sector is of great strategic importance to its economy. However, funding for transport infrastructure is overly dependent on public funds and is inadequate. Many businesspeople commute daily to the capital Dakar, which contributes about 60 % of GDP and is expected to have 5 million inhabitants by 2025. Due to outdated public transportation and poor road conditions, travel time to work is often unnecessarily long.[185] Moreover, the delivery of goods is often hindered by heavy traffic congestion in Senegal. Over 100,000 vehicles exit and enter the capital Dakar every day.[186]
These circumstances urgently need to be changed, as they are also directly related to the achievement of economic growth targets. In addition to adequate road maintenance, innovative solution mechanisms could also be one approach to change the current situation, thus effectively replacing obsolete public transport, for instance. However, this requires, among other things, technical support.[187]

[181] Cf. The World Bank Group, 'Country profile Senegal', p. 9-11.

[182] Cf. ibid., p. 12.

[183] Cf. Ndiaye, 'Senegal update', p. 13.

[184] Cf. The World Bank Group, 'Country profile Senegal', p. 12.

[185] Cf. The World Bank Group, 'Urban transport Senegal'.

[186] Cf. International Finance Corporation, 'Road Senegal'.

[187] Cf. The World Bank Group, 'Urban transport Senegal'.

Telecommunication

Senegal has first-class telecommunications facilities and the potential to develop value-added IT services such as software engineering. The country is increasingly positioning itself as a leading provider of ICT and teleservices in SSA.[188] In 2020, 43 % of the country´s population was using the Internet (an increasing trend).[189]

Energy

The lack of energy is one of the biggest obstacles to development in the country. Unfortunately, almost 60 % of the rural population still has no access to the national power grid.[190] Fortunately, the electrification rate in West Africa has increased significantly from 34 % (in the year 2000) to 53 % (in the year 2019). Despite its great progress in electrification, there is still work to be done to reliably connect the entire population to the electricity grid, as nearly half of the population still lacks electricity. The countries often lack the conditions to develop their renewable energy resources. Additionally, electricity bills are often significantly higher than in other parts of the world.[191]

Due to Senegal´s geographical location, the country has great potential in the field of renewable energies, in particular solar power.[192] For 2018, the government had set a target of generating at least 20 % of the electricity mix from renewable energy, which has been achieved. By comparison, in 2018, renewable energies accounted for around 36 % of electricity generation in Germany. The remaining electricity generation has so far been based on gas, oil, and coal, making Senegal highly dependent on fuel prices.[193]

Business environment

Senegal is characterized by democratic elections, peaceful changes of power, and high growth rates. It represents the economic and political anchor of stability in West

[188] Cf. Ndiaye, 'Senegal update', p. 15.

[189] Cf. The World Bank Group, 'Internet usage'.

[190] Cf. KfW, 'Senegal'.

[191] Cf. The World Bank Group, 'Power of energy'.

[192] Cf. KfW, 'Senegal'.

[193] Cf. ibid.

Africa. Additionally, the country aims to have the status of an "emerging economy" by 2035.[194]

However, the country also faces development problems and must overcome various hurdles. Despite high growth rates, private investment has fallen short of expectations in recent years, and the country remains one of the world's least developed.[195] Furthermore, Senegal is also characterized by growing public debt and low economic diversification.[196]

Nevertheless, there are several promising investment opportunities involving tourism, agriculture and agribusiness, seafood and aquaculture, extractive, health, and digital economy.[197]

Considering agriculture, proven investment opportunities are, for instance, post-harvest infrastructure (storage, packaging, transport), processing industries as well as (hydro-)agricultural development.[198]

Moreover, Sarah Diouf claims that Africa is becoming fashionable worldwide.[199] This statement will be discussed in more detail later in chapter 2.7.1.

At the end of the analysis, the following key findings can be compiled that are crucial to the development of the business ideas:

- insufficient productivity of the agricultural sector (high import rate),
- high youth unemployment,
- high dependence on fuel prices,
- lack of/limited access to electricity,
- heavy traffic congestion and outdated public transportation,
- one of the world´s least developed countries,
- rising temperatures,
- water sector threatened by climate change,
- increasing impact and risks of vector-borne and waterborne diseases,

[194] Cf. ibid.

[195] Cf. European Commission, ‘Senegalese economy’.

[196] Cf. KfW, ‘Senegal’.

[197] Cf. Ndiaye, ‘Senegal update’, p. 11.

[198] Cf. ibid., p. 12.

[199] Cf. Bogner and Hertzberg, ‘Zeit’, p. 23.

- most people employed in the agricultural sector (primarily small-scale),
- fishing as the second largest source of income and employer,
- 80 % of the population younger than 35,
- increasing urbanization expected in the future,

- one of the most politically stable countries in Africa,
- highly educated and skilled workforce,
- agriculture as the most dynamic engine of growth,
- high potential of significant energy resources (e.g., solar),
- rich in water resources,
- increasingly positioning as a leading provider of ICT and teleservices in SSA,
- first-class telecommunications facilities,
- African fashion becoming an attitude to attract,
- promising investment opportunities involving tourism, agriculture (including aquaculture), extractive, health, and digital economy.

Thus, the country's potential lies in the following areas:

- sustainable (climate-smart) agriculture,
- renewable energy,
- ICT,
- fashion,
- public transport/logistics,
- health,
- tourism,
- extractive.

2.4.4 Uganda

The second highest population growth in the world is found in Uganda.[200] The Vision 2040 for Uganda, presented in 2013, has already presented a concept that highlights the country's opportunities like geographical location, water resources, oil and gas, minerals, ICT sector, abundant labor force as well as industrialization and agriculture, which can be seized by the growing population.[201] The following section presents these opportunities, among others.

Country overview

Uganda is a landlocked country in East Africa, located in both, the southern and northern hemispheres. The country has a total surface area of 241,500 square kilometers, of which 17 % is covered by swampland and water.[202] The capital city of Uganda is Kampala, located north of Lake Victoria.[203]

Unfortunately, Uganda is one of the least developed countries in the world, although economic progress has been made in recent years.[204] In 2020, the GDP per capita (PPP) was 2,294.3 USD.[205]

Like the other sub-Saharan countries, Uganda is also struggling with various development problems. For example, soil erosion and degradation make agriculture difficult, and the consequences from climate change will further exacerbate problems such as floods or water shortages in the future.[206] The northern region represents the poorest area of Uganda, however, it decreased its poverty rate from 44 % in 2013 to 33 % in 2017. Moreover, the COVID-19 pandemic has further widened inequalities, with the education sector being the most affected.[207]

[200] Cf. The World Bank Group, ‘Country profile Uganda’, p. 2.

[201] Cf. National Planning Authority, ‘Vision 2040’.

[202] Cf. The World Bank Group, ‘Country profile Uganda’, p. 2.

[203] Cf. ibid., p. 11.

[204] Cf. KfW, ‘Uganda’.

[205] Cf. The World Bank Group, ‘GDP (PPP)’.

[206] Cf. The World Bank Group, ‘Country profile Uganda’, p. 2.

[207] Cf. World Bank, 'Uganda Women', p. 5.

Demography

Uganda's current population is estimated at 46 million.[208] In 2020, the country had a labor force of 16,497,309 people (an increasing trend).[209]

Over 48 % of the population is between 0 and 14 years old, making Uganda's age structure more skewed towards younger generations.[210] Under the most likely scenario, the population will at least double between 2020 and 2060, reaching 104 million people. As a result of this demographic boom, the population density will also increase significantly, and by 2055, the density will exceed the current Indian population density of 455 people per square kilometer. By 2060, the density is projected to reach 529 people per square kilometer, on par with South Korea.[211]

One consequence of the increasing population will be a significant shift from rural to urban areas. It is estimated that about 34 million people lived in rural Uganda in 2020, while about 11 million people, nearly 25 % of the population, lived in urban centers. However, it is projected that by 2060, the urban population will exceed the rural population, with estimates of 53 million people living in urban centers and 51 million people living in rural areas.[212]

Also, the demographic composition will change in the upcoming years. The working-age population is expected to increase from 24 million in 2020 to 69 million in 2060, which means that it will grow proportionally from 52 % of the total population today to almost 70 % by 2060.[213]

Like the countries previously analyzed, Uganda´s population is at risk from vector-borne and waterborne diseases. The World Health Organization estimates that by 2070, approximately 108 million people in Uganda will contract malaria annually. Moving forward, the health sector infrastructure must be modernized to improve both the sector's responsiveness and its resilience to climate change.[214]

[208] Cf. The World Bank Group, ‘Demographic Boom’.

[209] Cf. The World Bank Group, ‘Labor force’.

[210] Cf. AVSI, 'Productive Use of Electricity', p. 1.

[211] Cf. The World Bank Group, ‘Demographic Boom’.

[212] Cf. ibid.

[213] Cf. ibid.

[214] Cf. The World Bank Group, ‘Country profile Uganda’, p. 22-24.

Climatology

Uganda's largely tropical climate is characterized by two rainy seasons per year: the first from March to May, and the second from September to December.[215] The average total annual precipitation is 1,197 mm and the average temperature is about 22.8 °C.[216] Since the 1960s, average temperatures increased by 1.3 °C and are expected to continue to rise.[217]

Agriculture and natural resources

At the outset, it can be said that Uganda is fertile and rich in natural resources.[218] Figure 5 shows the agro-ecological zones of Uganda with their various agricultural products such as coffee, maize and fish that can be found due to climatic and geographical conditions.

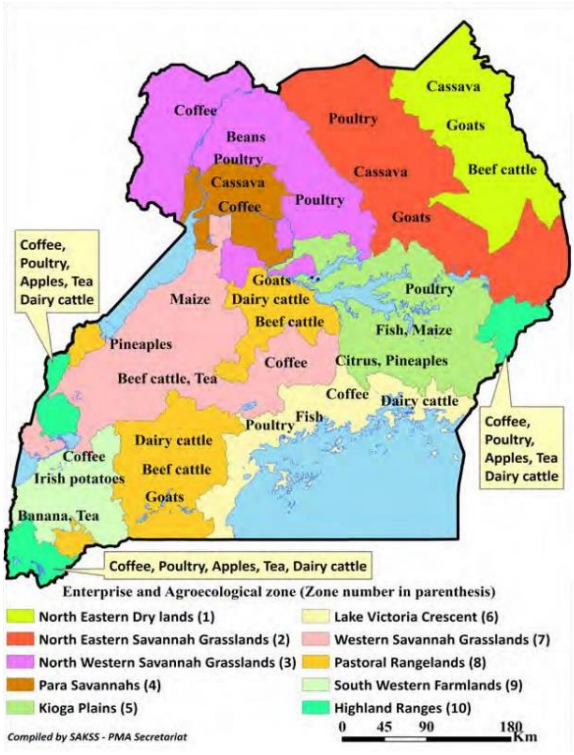

Figure 5 Uganda´s agro-ecological zones[219]

[215] Cf. The World Bank Group, 'Uganda Climatology'.

[216] Cf. ibid.

[217] Cf. The World Bank Group, 'Country profile Uganda', p. 5.

[218] Cf. KfW, 'Uganda'.

[219] The World Bank Group, 'Country profile Uganda', p. 15.

However, agriculture is mainly rain-fed and based on subsistence farming, which poses a challenge to farmers' food security and sustainability and makes the sector highly vulnerable to climate change and other hazards (especially droughts).[220]

The country´s agricultural sector has a major impact on economic prosperity as well as food security, accounting for 27 % of GDP and employing 73 % of Uganda´s labor force.[221]

Due to the COVID-19 pandemic, many jobs were lost, and businesses closed, in response to which many people returned to agriculture and other natural resource-dependent activities. This increased pressure on natural resources, which were already stretched by urbanization, rapid population growth, etc. An estimated 41 % of Uganda's soils are degraded, contributing to economic vulnerability and poverty. The extent of soil erosion and degradation is unstoppable and costs approximately 17 % of Uganda's GDP.[222]

The agricultural sector remains the most important source of exports, accounting for 46 % of total exports.[223] The major export crops include coffee, tea, and fish but these may experience losses due to climate change. It is estimated that economic losses could reach 1.4 billion USD by mid-century.[224]

Fish farming represents the country's second-largest export earner and provides an important source of livelihood for approximately 700,000 to 1.2 million people. In recent years, this export has increased significantly. The fisheries industry is based on inland fishing, with about 50 % of the total national fish catch coming from Lake Victoria. However, the sector is increasingly burdened by rising fishing efforts, which is putting severe pressure on capture fisheries, leading to fish shortages and the use of destructive fishing gear and technologies.[225] In addition, fishing is under severe threat from climate change, which is leading to reduced water availability.[226] In conclusion, it can be said that to increase Uganda's productivity, income and environmental

[220] Cf. CIAT and BFS/USAID, 'Climate-Smart Agriculture', p. 1.

[221] Cf. ibid., p. 2.

[222] Cf. The World Bank Group, 'Economic Update'.

[223] Cf. CIAT and BFS/USAID, 'Climate-Smart Agriculture', p. 2.

[224] Cf. The World Bank Group, 'Country profile Uganda', p. 15.

[225] Cf. ibid., p. 25-24.

[226] Cf. ibid., p. 14, 15.

benefits and protect the livelihoods of many Ugandans, there is a need to invest in sustainable land management and climate-smart agriculture innovations.[227]

Traffic and transport

The rapid development of the country has led to a significant increase in its transportation sector. This includes both individual transport with their vehicles and the use of shared transport. The country´s transport sector is dominated by road transport. Compared to the country's regional neighbors, Uganda has the highest percentage of road networks, but just 67 % of all households have access to usable roads all year round. Also, motorization levels are very low, compared to the motorization level of SSA, with just 9.3 vehicles (including 3.4 motorcycles) per 1,000 Ugandans.[228]

In a survey conducted by the international company Deloitte, it was found that most Ugandans use expensive and unsafe ridesharing services for their daily commute. In Uganda, the most common form of motorized transport and one of the most satisfactory forms (after private vehicles) are Boda-Bodas (57 %).[229]

A negative consequence of the expansion and improvement of road infrastructure is an increase in emissions. The transport sector represents one of the sectors with the highest greenhouse gas emissions.[230] To make the transport sector more profitable, there is a need to introduce less vulnerable infrastructure that can both provide cost-effective services and reduce greenhouse gas emissions.[231]

Telecommunication

Uganda has auspicious growth prospects for the development of a world-class IT industry as well as IT services.[232] Its ITC sector is one of the fastest growing and vibrant sectors within the Ugandan region.[233] Developments in ICT have dramatically changed the way of the collection, storage, processing, and usage of information,

[227] Cf. The World Bank Group, ‘Economic Update’.

[228] Cf. The World Bank Group, ‘Country profile Uganda’, p. 26.

[229] Cf. Deloitte, ‘Consumer perspective’, p. 82-85.

[230] Cf. The World Bank Group, ‘Country profile Uganda’, p. 26.

[231] Cf. ibid., p. 26-27.

[232] Cf. Republic of Uganda, ‘ICT Uganda’, p. 25-26.

[233] Cf. Ministry of ICT & National Guidance, ‘ICT sector Uganda’.

making it the most powerful tool for modernization. In Uganda, ICT is used in various areas as a tool for economic and social development.[234] However, in 2020, only 20 % of the country´s population was using the Internet (an increasing trend).[235] The Ministry of Information and Communications Technology makes it clear that women and young people can make a positive contribution to the growth of ICT on the one hand, and that ICT can in turn serve as an empowerment tool for these groups. Therefore, it is very important to involve them.[236]

Energy

AVSI Foundation implemented the Productive Use of Electricity program for smallholder farmers and rural entrepreneurs in 15 villages electrified through newly established mini-grid projects in Isingiro and Rakai districts starting in December 2018. The aim was to increase the impact of rural electrification by promoting the productive use of electricity. A total of 250 households and 329 micro, small and medium enterprise business owners were interviewed, just over half of whom were female respondents.[237] Through the program, it was found that for 77 % of micro, small and medium enterprises, access to electricity is the most frequently cited barrier to business growth. For example, 41 % of surveyed households and 54 % of surveyed micro, small and medium enterprises in the village of Burumba indicated that they have the necessary technical skills to start new businesses, but the lack of electricity, as well as the lack of capital, prevent them from doing so.[238]

In addition, it was figured out that 97 % of households surveyed would be willing to pay for electricity in case the grid reaches their environment.[239]

Moreover, the survey has shown that on average, 67.6 % of micro, small and medium enterprises in the 15 villages would both expand their existing business and start a new business if electricity was available 24/7.[240] Refrigerators and milling machines are the most frequently mentioned potential electrical equipment to increase the

[234] Cf. Waema and Adera, 'ICTs Africa', p. 244-245.

[235] Cf. The World Bank Group, ‘Internet usage’.

[236] Cf. Republic of Uganda, ‘ICT Uganda’, p. 34.

[237] Cf. AVSI, 'Productive Use of Electricity', p. 3–110.

[238] Ibid., p. 10, 18, 23.

[239] Cf. ibid., p. 14.

[240] Cf- ibid., p. 24–114.

profitability of existing micro, small and medium enterprises and income-generating activities, as well as for potential new enterprises.[241]

In Uganda, the predominant and traditional source of energy consumption is biomass, but the effects of climate change are projected to negatively impact its availability.[242] 91 % of micro, small and medium enterprise respondents to the Productive Use of Electricity program use solar energy and own the panels. Owning your own solar panels reduces the monthly expense for energy to zero. However, an initial investment of between 150,000 and 3 million Uganda shillings must be made.[243] To achieve development goals and better withstand climate change, investments in effective energy generation, transmission, as well as utilization are crucial.[244]

Business environment

Compared to the other countries in SSA, the female labor force participation rate was higher in Uganda. Women account for 40 percent of all business owners, which makes the country one of seven countries worldwide that has achieved parity of entrepreneurial activity.[245] However, companies run by women are on average smaller (5-50 employees) and more restricted than companies run by men. For instance, in terms of access to market information, technology, larger loans, longer repayment periods and the size of capital they have. Women-owned businesses are often present in less productive and less profitable sectors. In terms of profits, they differ by 30 %, to the disadvantage of women.[246] One of the reasons for this parity of entrepreneurial activity is the women´s predominance in subsistence agriculture. This is also evident in Figure 6 (next page). Men predominate in sectors associated with higher skills and higher wages as well as the transition to industrialization.[247] Also in the agricultural sector, a woman earns almost half as much as a man (women: 58 USD per month; men: 92 USD per month).[248] To bring male-dominated sectors closer to women, they

[241] Cf. ibid., p. 15.

[242] Cf. The World Bank Group, 'Country profile Uganda', p. 21.

[243] Cf. AVSI, 'Productive Use of Electricity', p. 13, 24.

[244] Cf. The World Bank Group, 'Country profile Uganda', p. 22.

[245] Cf. World Bank, 'Uganda Women', p. 28-29.

[246] Cf. ibid., p. 51-52.

[247] Cf. ibid., p. 28-29.

[248] Cf. CIAT and BFS/USAID, 'Climate-Smart Agriculture', p. 2.

need to have more information about the sectors (including the prospect of higher profits), encouragement, and even assurance of safety.[249]

The Uganda Economic Update shows that the country had already lost an estimated 61 billion USD due to gender inequality before the COVID-19 shock. [250] To drive Uganda's economic recovery more sustainably, faster, and stronger, more women must be placed into the center of profitable economic activities, particularly large ones.[251] There is also a need to create more productive and rewarding work in agriculture.[252]

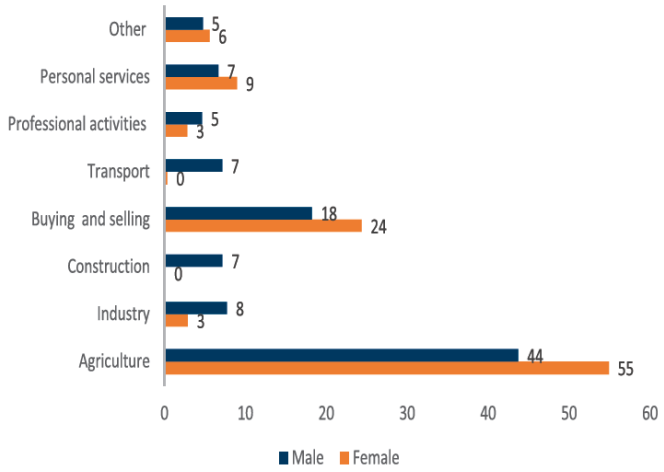

Figure 6 Pre-lockdown economic sectors of employment, by sex (% of employed population)[253]

At the end of the analysis, the following key findings can be compiled that are crucial to the development of the business ideas:

- one of the world´s least developed countries,
- high dependence on rain-fed agriculture (based on subsistence farming),
- great inequalities between women and men,
- companies run by women on average smaller and more restricted and less profitable than companies run by men,
- lack of/limited access to electricity,

[249] Cf. World Bank, 'Uganda Women', p. 52-55.

[250] Cf. World Bank, ‘Gender Equality’.

[251] Cf. ibid.

[252] Cf. World Bank, 'Uganda Women', p. 38.

[253] Ibid., p. 31.

- 👎 expensive and unsafe ridesharing services for the daily commute,
- 👎 rising temperatures,
- 👎 water scarcity,
- 👎 low use of the Internet by the population,
- 👎 the highest percentage of road networks, but just 67 % of households have access to usable roads all year round,
- 👎 due to COVID-19, many jobs were lost, and businesses closed, leading to a return to agriculture and other natural resource-dependent activities

- ☞ second highest population growth worldwide,
- ☞ over 48 % of the population between 0 and 14 years old,
- ☞ expected increasing working age population (69 million in 2060),
- ☞ increasing urbanization expected in the future.
- ☞ the predominance of women in the agricultural sector,
- ☞ Boda-Bodas are the most common form of motorized transport,
- ☞ the agricultural sector most important source of exports,
- ☞ fish farming is the second largest export earner (increasing trend) and an important source of livelihood,
- ☞ major export crops include coffee, tea, and fish (threatened by climate change),
- ☞ refrigerators and milling machines are most frequently mentioned as potential electrical equipment to increase the profitability of existing micro, small and medium enterprises and income-generating activities,

- 👍 high female labor force participation rate,
- 👍 ICT sector is one of the fastest growing and vibrant sectors (can serve as an empowerment tool for women and young people),
- 👍 significant increase in the transportation sector (dominated by road transport),
- 👍 91 % of micro, small and medium enterprise respondents to the Productive Use of Electricity program use solar energy and own the panels,
- 👍 women and young people can make positive contributions to the growth of ICT.

Thus, the country's potential lies in the following areas:

- sustainable (climate-smart) agriculture,
- fishing,
- ICT sector.
- renewable energy,
- logistics,
- ICT.

2.5 Productive use through natural resources

This thesis highlights certain natural resources that, on the one hand, successfully address the problems that countries face, but also exploit the identified potentials of each country. These natural resources are water, plants and fish, as well as hemp, which are now discussed in more detail below.

2.5.1 Aquaponics

As revealed by the analysis of the countries, most people are employed in the agricultural sector. The sector is therefore indisputably crucial for the continent, although it struggles with various challenges. The four countries studied will face increasingly considerable problems in the future, such as water scarcity, land degradation, overfishing, and climate change. In addition, the African population will continue to grow in the coming years, accompanied by increasing urbanization.

On the one hand, this means that demands on food production will increase and resources such as water, nutrients, and land will be under ever greater strain.

On the other hand, urbanization means that the future of agriculture is not limited to rural areas.

However, agricultural technologies need to be adapted to the urban environment and to meet the increasing demand for food without exploiting natural resources, there is an urgent need for alternative, sustainable methods.[254]

Aquaponics is one of the most efficient ways to address these challenges in SSA sustainably. It has already arrived in Africa. Egypt, Nigeria, Kenya, and South Africa are leading in the adoption of aquaponics. Although aquaponics systems have higher start-up costs in general at this time, their potential to be economically viable when operated by local materials is particularly high.[255]

The largest aquaponic hub on the continent is called Ichthys Aquaponics Group.[256]

But what exactly is aquaponics?

Aquaponics can be defined as an integrated closed loop system that combines hydroponics (cultivating plants in nutrient-enriched water) with recirculating

[254] Cf. Goddek et al., 'Aquaponics', p. 3.

[255] Cf. Obirikorang et al., ‘Improved food security’, p. 1, 4, 8.

[256] Cf. Aquaponics Africa, ‘Home’.

aquaculture (raising aquatic animals (fish) in tanks).[257] Accordingly, both plants and fish, are produced from one water source. Therefore, water is the most important medium in aquaponic systems.[258] Figure 7 illustrates the flow of water within a coupled system.[259] Solar energy can be used to pump water into a growing system and for temperature control.[260]

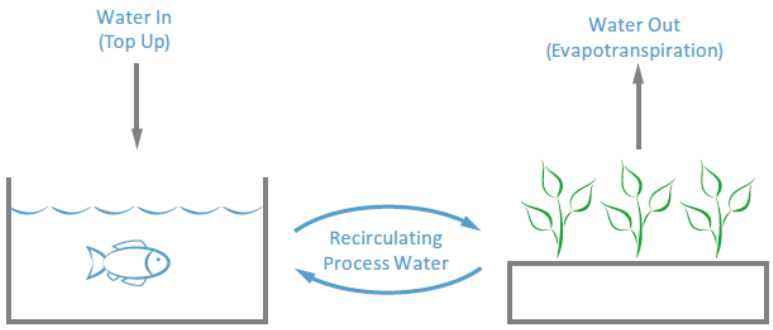

Figure 7 Main water flows within a coupled aquaponics system[261]

In simplified terms, the aquaponics process is as follows: the fish eat the feed, use some of the nutrients they need, and release the rest as waste (consisting of urine, feces and gill excretions). This waste is then partitioned between the microbes, the plants, and the system water.[262]

The fish feed, the buffers used to help control and adjust the pH values of both the fish and the plants, and any external nutrient additions or supplements needed to meet the nutrient needs of the fish and plants are among the most important nutrient inputs to an aquaponic system.[263]

Plant culturing and fish culture technologies that do not inherently use or consume the supplied nutrient and water resources destructively should be used.[264] For instance, a study has found that koi and tilapia are the most suitable fish species for aquaponics development in Namibia. With an annual growth rate of 12.5 % in Namibia,

[257] Cf. Tyson et al., ‘Aquaponic Systems’, p. 6.

[258] Cf. Goddek et al., 'Aquaponics', p. 124.

[259] Cf. ibid., p. 12, 114, 118.

[260] Cf. World Economic Forum, ‘Opportunities for circular economy’, p. 15.

[261] Goddek et al., 'Aquaponics', p. 118.

[262] Cf. ibid., p. 116.

[263] Cf. ibid., p. 124.

[264] Cf. ibid., p. 121-122.

aquaponics is a very lucrative agricultural system due to potential local market expansions and short- and long-term profit margins. [265]

Optimally, the fish are kept in tanks made of materials such as plastic, fiberglass, concrete, etc., and thus do not remove nutrients from the water.[266] As for the choice of crop, it was found that instead of fruiting vegetables, leafy vegetables achieve higher profitability.[267]

In addition to many environmental benefits, aquaponics also brings economic benefits, as aquaponics is theoretically capable of increasing the overall value of fish farming or conventional hydroponics while closing the loop of water, food, and energy within a bio-based circular economy. In addition, it can compress and condense production in places not normally used for growing food. For instance, in cities, it can be used on unused or underutilized land such as building lots, flat roofs, housing developments and schools, or abandoned factories. [268] Indeed, since aquaponics is a soil-less system, it is independent in terms of location and soil availability, which is a major advantage over soil-based agriculture.[269]

In both developed and developing countries, aquaponics allows people to reclaim part of the food production process by bringing fresh local food to market.[270]

Fish in particular plays an important role in improving malnutrition, especially for pregnant and lactating women and children.[271] One of the most efficient animal protein producers is fish.[272] Unfortunately, as mentioned in the country analysis, fishing grounds are already overfished.

However, the demand for fish continues to increase, making aquaculture the fastest-growing sector of global food production.[273] In terms of global food supply, more fish protein is now supplied by aquaculture than by capture fisheries.[274] Aquaponics can

[265] Cf. Obirikorang et al., ‘Improved food security’, p. 4.

[266] Cf. Goddek et al., 'Aquaponics', p. 121-122.

[267] Cf. Goddek et al., ‘Aquaponics challenges’, p. 4215.

[268] Cf. Goddek et al., 'Aquaponics', p. 13.

[269] Cf. ibid., p. 139.

[270] Cf. ibid., p. 13.

[271] Cf. Obirikorang et al., ‘Improved food security’, p. 6.

[272] Cf. Goddek et al., ‘Aquaponics challenges’, p. 4214.

[273] Cf. ibid.

[274] Cf. Goddek et al., 'Aquaponics', p. 31.

provide nutritious plant foods and even fish in urban and rural areas throughout the year.[275]

It is worth highlighting that the water footprint of aquaponic systems is significantly better than traditional agriculture. As shown in Figure 8, fish in recirculating aquaculture systems (RAS) use the least water of all food production systems.[276]

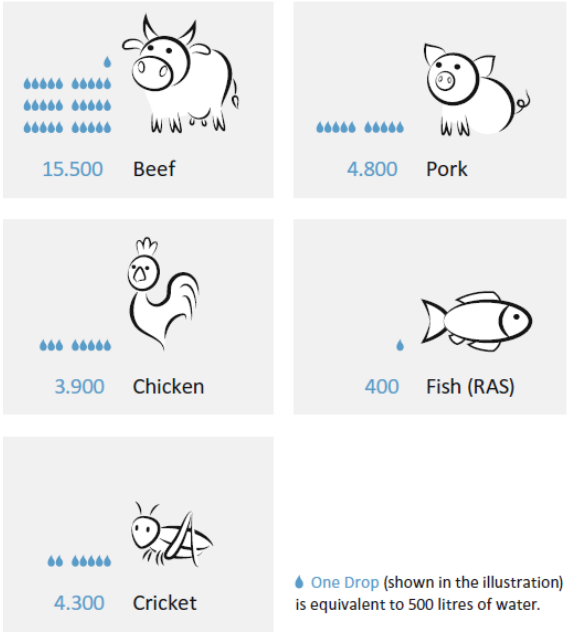

Figure 8 Water footprint (liters of water per 1 kg)[277]

Through analysis, it was found that areas suffering from water scarcity will particularly benefit from aquaponics technology being operated in a commercial setting.[278] Profits are about 30 times higher than in traditional farming, after deducting operating costs, due to the more efficient use of space and the additional income from fish.[279] Additionally, it has also been found through a market survey (Kenya) that customers are willing to pay more for aquaponic products because they are healthier, fresher and pesticide free.[280]

[275] Cf. Karaki, Al, 2022.

[276] Cf. Goddek et al., 'Aquaponics', p. 26-27.

[277] Ibid., p. 26.

[278] Cf. Goddek et al., 'Aquaponics challenges', p. 4199.

[279] Cf. Obirikorang et al., 'Improved food security', p. 3.

[280] Cf. ibid., p. 5.

Also, during the webinar "Scaling Productivity with New Agriculture Technology" held by the African Alliance, which is one of the regional chapters of the EU Tech Chamber, this type of production system was highlighted in the panel discussion and first presented by Al Karaki, founder and CEO of 4iAfrica. 4iAfrica is a business of technology services and products which was born from the need to innovate for ecological and social development. The focus is on developing agriculture, energy, ICT, and education to bring about sustainable change.[281]

So, in summary, an increase in productivity, as well as profitability, can be achieved through the adoption of aquaponics without a net increase in water use. Additionally, resources are better utilized through, for example, the collection and reuse of nutrients and water, and environmental impacts are lower. Furthermore, farmers can diversify their agriculture into higher-value crops and species.[282] Raising awareness and implementing aquaponics will help address food insecurity through the provision of vegetables and fish.[283]

Aquaponics projects could be supported by various development agencies, such as the United States Agency for International Development (USAID), the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (German Society for International Cooperation; in short GIZ;) the African Union Development Agency - New Partnership for Africa´s Development (AUDA-NEPAD) and the African Foundation for Development (AFFORD).[284] Potential key partners could be – next to (smallholder) farmers, schools, universities and the government – the Tilapia Aquaculture Association of Southern Africa and the Aquaculture Research and Development Centre.[285]

Potential payment service providers for secure transactions could be MFS Africa, Vantagepay, PayPal and Apple Pay.[286]

[281] Karaki, Al, 'Sustainable Business'.

[282] Cf. Goddek et al., 'Aquaponics', p. 114.

[283] Cf. Obirikorang et al., 'Improved food security', p. 6.

[284] Cf. USAID, 'What we do'; GIZ, 'Profil'; African Union Development Agency, 'Homepage'; African Foundation for Development, 'AFFORD'.

[285] Cf. Aquaculture Association of Southern Africa, 'About'; Water Research Institute, 'Homepage'.

[286] Cf. MFS Africa, 'Digital payments gateway'; Vantagepay, 'About'; PayPal, 'For SMEs'; Apple Inc., 'Apple Pay'.

2.5.2 Hemp

The plant and its cultivation

Hemp is a promising resource for African farmers and entrepreneurs in the future. The location on the equator is crucial for cultivation, as the plant needs 12 hours of sunshine and 12 hours of darkness to flower.[287] In addition, high-altitude mountainous regions, such as in Lesotho, have rich, fertile soil and abundant water sources, which are optimal conditions for cultivation.[288] In these optimal locations, harvesting can take place every three to four months without interruption. The advantage of growing on the equator is that less needs to be invested in energy and therefore there are fewer costs, which also makes the final product cheaper.[289] In principle, hemp can be sown at any time, as long as the soil conditions (temperature and humidity) are optimal and is not dependent on a specific date.[290] The agricultural expertise in Africa that is predominantly available through illegal cultivation can be a decisive advantage.[291]

According to experts, the south of the continent is also suitable for the cultivation of hemp, because, in addition to an ideal climate, there is enough land area with clean soil and a lot of available labor. Furthermore, Africa has high-quality varieties of cannabidiol (CBD), the component of female plants that is suitable for medicinal (and recreational) use, which is a huge competitive advantage.[292]

Hemp farming for medicinal and industrial use is legal in the following African countries: Ghana, Lesotho, South Africa, Malawi, Rwanda, Zambia, Zimbabwe, and Uganda.[293]

Since October 2020, the cultivation and export of medical cannabis have been legal in Rwanda, but its use remains illegal. Furthermore, the farms must be equipped with surveillance cameras and streetlights, as well as guards on watchtowers. Investors

[287] Cf. Schlindwein, ‘Cannabis’.

[288] Cf. Prohibition Partners, ‘Cannabis Report’, p. 7.

[289] Cf. Schlindwein, ‘Cannabis Uganda’.

[290] Cf. Businessideas4Africa, ‘Hemp guide’.

[291] Cf. Prohibition Partners, ‘Cannabis Report’, p. 7.

[292] Cf. Euronews, ‘Cannabis production’.

[293] Cf. Businessideas4Africa, ‘Hemp guide’.

interested in cultivating and exporting medical hemp in Rwanda must apply for licenses from the local Food and Drug Administration (FDA).[294]

In Uganda, medical cannabis is being cultivated for export to Europe. However, in Uganda, an export license costs 5 million USD.[295] There is currently one legal cannabis plantation (Industrial Globus Uganda Ltd.) in Uganda at the foot of the Rwenzori Mountains, very close to the equator, with over 40,000 plants spread over three hectares.[296] More than 150 Ugandans work there, most of them women.[297]

Since the beginning of the year 2022, Ugandan cannabis is also available in German pharmacies. There are currently about 300,000 patients in Germany, and even with this not too large number, there are supply bottlenecks. There are over 25,000 cannabis cultivation licenses worldwide, but only about 20 licenses for importation into Germany. German entrepreneur and co-founder of Cantourage Patrick Hoffmann came up with the idea of making an offer to these 25,000 companies so that they supply Cantourage with the raw materials and then Cantourage makes the certified drug in Germany. The advantage for these companies would be to bypass the laborious process of obtaining an import license to Germany. Meanwhile, his company sources as a platform from 19 partners in fourteen different countries. In addition to traditional growing countries such as Israel and Canada, the African countries Uganda, Zimbabwe, South Africa, and Lesotho are also included.[298]

Commercialization

In fact, for 22,000 different industrial purposes, the hemp fiber can be used.[299] Due to its high wet strength, it serves as a useful raw material for ropes, cordage, and textiles. Hemp can also be used as a raw material for paper, building material (insulating fleece or fiber cement), stable bedding, seeds as food (muesli ingredient), fish bait, bird feed, fuel, whole plants for heat energy production as well as for oil production.[300]

[294] Cf. Businessideas4Africa, ‘Hemp Rwanda’.

[295] Cf. Schlindwein, ‘Cannabis Uganda’.

[296] Cf. Schlindwein, ‘Cannabis’.

[297] Cf. Schlindwein, ‘Economic boom - Cannabis’.

[298] Cf. Schlindwein, ‘Cannabis’.

[299] Cf. Deutschlandfunk, ‘Hemp products’.

[300] Cf. Diepenbrock et al., 'Ackerbau', p. 214.

Hemp seeds are very suitable for the food industry.[301] Seeds can be ordered online with permission or purchased from African seed banks. For instance, in South Africa, there are already several seed banks that include various seeds, such as Marijuana Seeds SA, Sacred Seeds and Green Smoke Room Seeds. African hemp farmers can also buy the seeds in many pet food stores and pharmacies.[302]

Also, during the webinar "Scaling Productivity with New Agriculture Technology" held by the African Alliance, the versatility of hemp was pointed out by Al Karaki and was on the agenda in the subsequent panel discussion. Karaki explained that thousands of products can be made with hemp, in various fields: pharmaceuticals, food industry, construction industry, biodegradable hygiene products like diapers, etc.[303]

Moreover, the increasing sophistication of the African alcohol market could be seen as an additional indication of how hemp products could gain popularity. Breweries like the Durban-based beer company Poison City Brewing have already produced cannabis beers. But hemp has also already been used to produce gin.[304] Perhaps using hemp to make wine would be a promising business model in the future, as wine consumption in Africa has grown five times faster than the global average and could represent untapped potential.[305]

African hemp market

The hemp industry is growing faster than any other industry. Ten times more legal cannabis was exported in 2021 than in 2020 (over 15 tons). Major exporters include the countries South Africa, Uganda, and Lesotho.[306] Africa is already preparing for the legal cannabis onslaught. A gigantic industry is developing that could soon take over global supply, both in terms of pharmaceuticals and stimulants.[307]

According to the United Nations, it is estimated that at least 38,000 tons of African cannabis are produced per year and thus cultivation is widespread throughout the

[301] Cf. Agrarheute, 'Hemp'.

[302] Cf. Businessideas4Africa, 'Hemp guide'.

[303] Karaki, Al, 'Sustainable Business'.

[304] Cf. Prohibition Partners, 'Cannabis Report', p. 34.

[305] Cf. ibid., p. 18.

[306] Cf. Schlindwein, 'Economic boom - Cannabis'.

[307] Cf. Schlindwein, 'Cannabis'.

continent, but it is (still) illegal in most African countries.[308] Apart from South Africa and Lesotho, cannabis for recreational use is illegal in all African countries.[309] In Lesotho, South Africa, Zambia, Zimbabwe and Ghana, medicinal cannabis is legal.[310] Cannabis as medicine is already highly accepted in Southern and Eastern Africa, and if the treatments prove successful, it will spread even further.[311]

The continent has one of the highest consumption rates worldwide (see Figure 9). Five of the 30 countries with the highest prevalence of cannabis use among the adult population (15-64 years old) are in Africa. These include Nigeria (14.9 million consumers), Zambia (880,000 consumers), Madagascar (1.3 million consumers), Egypt (3.8 million consumers), and Sierra Leone (220,000 consumers).[312] With over 76 million black market users, Africa has a huge potential user base.[313] As urbanization increases, so will the demand and popularity of CBD products in Africa, as urban consumers are more affluent than rural populations.[314]

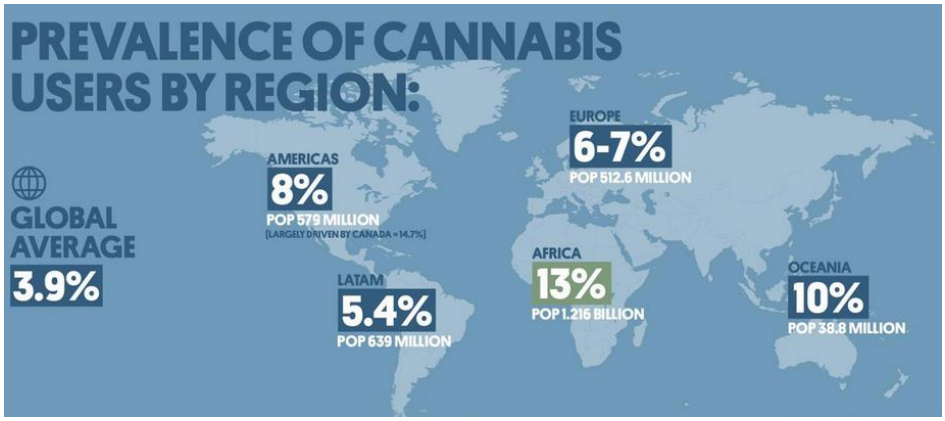

Figure 9 Prevalence of cannabis users by region[315]

Aside from being easier to grow than other traditional crops, hemp has also proven to be much more lucrative than traditional crops such as sugar cane and corn. In Congo, for example, 100 kilograms of cannabis can sell for 96 USD to 128 USD, while the

[308] Cf. Prohibition Partners, 'Cannabis Report', p. 7.

[309] Cf. ibid., p. 18; Businessideas4Africa, 'Legalization'.

[310] Cf. Prohibition Partners, 'Cannabis Report', p. 22-24; Businessideas4Africa, 'Legalization'.

[311] Cf. Prohibition Partners, 'Cannabis Report', p. 17.

[312] Cf. ibid., p. 27.

[313] Cf. Prohibition Partners, 'Cannabis industry'.

[314] Cf. Prohibition Partners, 'Cannabis Report', p. 18.

[315] Prohibition Partners, 'Cannabis industry'.

same weight of corn can fetch only 54 USD.[316] The famous Swazi and Malawi Gold cannabis, which is wrapped in banana leaves and dried after harvest, making it special, could help create a brand identity, increasing the cost per gram.[317]

African lobby groups, key consumer groups and high-profile campaigners define the key consumer groups. These include the Africa Cannabis Association (Kenya), Cannabis Development Council of South Africa, National Hemp Foundation (South Africa), which tries to coordinate the emerging hemp industry, The Dagga Couple (South Africa), Fields of Green For All, as well as Omoyele Sowore (Nigeria).[318]

Among the companies already established and operational in the African hemp business is, for example, Industrial Globus Uganda Ltd., a joint venture between an Israeli and a Ugandan company.[319] Another joint venture is CannInvest Africa (between Aphria and Verve Group), which both supplies medicinal extracts to African countries where cannabis is legalized and supplies Aphria's existing global markets.[320] Lesotho is home to WeGROW, which is licensed not only to grow but also to process, extract, package and export.[321] Invegrow Limited, located in Malawi, also owns several greenhouses for the cultivation of hemp.[322] Eco Equity, a British company founded by Zimbabwean entrepreneur Jon-Paul Doran, operates a greenhouse in Zimbabwe aimed at the European market.[323]

Moreover, there is Medigrow Africa, a network of legal cannabis growers on the African continent for global distribution.[324] ASIF420 supports cannabis businesses worldwide and has partnered with global leaders to create a unique international platform for the development of CBD products.[325] Consultancies for the BioMedicine

[316] Cf. Prohibition Partners, 'Cannabis Report', p. 17.

[317] Cf. ibid., p. 13.

[318] Cf. ibid., p. 27-30.

[319] Cf. Schlindwein, 'Cannabis'.

[320] Cf. Prohibition Partners, 'Cannabis Report', p. 34.

[321] Cf. WeGROW, 'Homepage'.

[322] Cf. Invegrow, 'Homepage'.

[323] Cf. Deutschlandfunk, 'Hemp products'.

[324] Cf. Medigrow, 'Homepage'.

[325] Cf. ASIF 420, 'Homepage'.

and CBD industry also include Seed to Science Ltd. with an office in Johannesburg.[326] Africanpure is an online store with various CBD products.[327]

According to estimates by the British market research company Prohibition Partners, the value of African-produced hemp products and related goods will be 7.1 billion USD in 2023.[328] 6.3 billion USD relates to the market value of recreational cannabis and 0.8 billion USD relates to the market value of medical cannabis.[329]

Assuming the cannabis industry is fully legalized and regulated, Nigeria and South Africa potentially represent the two most valuable markets for medical cannabis in the region.[330] Since Nigeria has a lot of drug manufacturers and the capacity of the production sector is highly underutilized (40 %), it could act as a key country for medical cannabis. Morocco is described as an emerging player in the global pharmaceutical market due to its convenient location.[331]

Sustainability

The plant is also very sustainable. One hectare of hemp can absorb four times more carbon dioxide from the atmosphere than normal greenery.[332] According to calculations, one kilogram of hemp grown indoors consumes up to five tons of CO_2.[333]

[326] Cf. Seed To Science, 'Homepage'.

[327] Cf. Africanpure, 'Homepage'.

[328] Estimates assume that by 2023, South Africa, Zimbabwe, Lesotho, Nigeria, Morocco, Malawi, Ghana, Eswatini, and Zambia will have legalized medical cannabis and regulated recreational use.

[329] Cf. Prohibition Partners, 'Cannabis Report', p. 15.

[330] Cf. Prohibition Partners, 'Africa Cannabis'.

[331] Cf. Prohibition Partners, 'Cannabis Report', p. 17-18.

[332] Cf. Deutschlandfunk, 'Hemp products'.

[333] Cf. Schlindwein, 'Economic boom - Cannabis'.

2.6 Productive use through energy

Between 2000 and 2012, energy demand in SSA increased by about 45 % with an increasing trend.[334] As already mentioned at the beginning, for West Africa alone, where Senegal is located, it is forecast that regional electricity consumption will increase by 100 % by 2030. Though, this would be accompanied by an estimated 102 % increase in carbon emissions.

Renewable energy, however, can be used to reduce carbon intensity on the one hand and make one self-sufficient on the other.[335]

To sustainably meet the increasing demand and reduce carbon emissions, innovative business models need to be implemented in the existing market. The following section identifies various options for productive use through (renewable) energy. Furthermore, this chapter also presents a way in which renewable energy can be used to partially solve the prevalent problem of PHL in SSA.

What can be said in advance is that the market for business models that slow down non-renewable energy flows is large and growing.[336]

2.6.1 Coffee roasting with the help of sunlight

Around 70 % of the world's harvested coffee is exported to industrialized countries for further processing, as there is a lack of processing and logistics facilities in the coffee-producing countries. As a result, producers receive only a small economic return.[337] Solar energy can be used to further process the harvested beans, bringing much of the value chain back to the producing countries.

The Italian startup PuroSole has already recognized and seized this opportunity. On the outskirts of Rome, up to 300 kilos of roasted coffee can be produced on a sunny day with the help of sunlight, without emissions and conventional energy consumption. Mirrors focus the sun's rays (see Figure 10, next page) to reach temperatures of 200 °C to 300 °C. The roasting begins cold as soon as the sunlight illuminated the beans. So, the beans are roasted by direct irradiation - namely by the electromagnetic energy of the light emitted by the sun - and not by the heat of the sun

[334] Cf. Shimeles et al., 'Agriculture in Sub-Saharan Africa', p. 97-98.

[335] Cf. The World Bank Group, ‘Power of energy’.

[336] Cf. World Economic Forum, ‘Opportunities for circular economy’, p. 16.

[337] Cf. Majeed et al., ‘Solar roaster’, p. 1-2.

or by contact with hot air, as is often the case with traditional processes.[338] This makes the process very energy efficient. In comparison, traditional roasting techniques are energy-wasting, time-consuming, and uncontrolled. Furthermore, many large-scale roasters are not affordable to smallholder farmers.[339]

Figure 10 Solar roasting system[340]

A solar roasting process takes about ten to fifteen/twenty minutes and is also gentler on the beans than conventional roasting, because the roasting process naturally takes place, on the one hand, and is shorter, on the other. The beans are not burned as much by the shorter roasting and can therefore better retain their ingredients. Additionally, the degree of roasting between the inner and outer parts of the coffee bean is more uniform when roasted by sunlight, which improves the organoleptic characteristics[341]. Moreover, compared to a traditional roasting system with the same productivity, the roasting system using solar energy can enable an annual saving of about 60,000 kWh to produce 30,000 kg of coffee.[342]

The process using solar energy is much more environmentally friendly than the classic roasting processes. In fact, for every 1000 kg of coffee roasted with the sun compared

[338] Cf. PuroSole, 'Technology'.

[339] Cf. Majeed et al., 'Solar roaster', p. 2.

[340] PuroSole, 'Solar Coffee Roasting'.

[341] See Glossary.

[342] Cf. PuroSole, 'Solar Coffee Roasting'.

to the processes using gas, the production and release of over 400 kg of CO_2 into the atmosphere is avoided.[343]

In addition to coffee beans, the key resources of each configuration include groups of reflectors (heliostats), an impeller (roasting drum), and a control unit. Expanding the key resources leads to an increase in productivity and can easily take place at any time.[344]

The automatic reflector (see Figure 11) is the basic component of the system. It consists of a motorized electromechanical device on two axes, controlled by an optoelectronic system with two processors. Additionally, it is made up of a reflective surface (mirror) of approximately 0.5 square meters.[345] To ensure the energy needed for the roasting process, about two square meters of solar collector mirrors must be used for each kilogram of raw coffee.[346]

Figure 11 Automatic reflector[347]

The reflector is completely autonomous and is powered directly by sunlight, thus no external energy source is required. The advantage of autonomy is very high system reliability. Even if one device has a malfunction, the other devices can usually continue to work, and production is not interrupted. The reflector ensures that the reflected solar radiation is concentrated directed onto the roasting rotor, independent of the current position of the sun.[348]

To keep the sun rays at a fixed point during the day, the inclination of the mirrors is automatically adjusted according to the change in the position of the sun.[349] The main

[343] Cf. PuroSole, 'Technology'.

[344] Cf. PuroSole, 'Solar Coffee Roasting'.

[345] Cf. ibid.

[346] Cf. PuroSole, 'Technology'.

[347] PuroSole, 'Solar Coffee Roasting'.

[348] Cf. ibid.

[349] Cf. PuroSole, 'Technology'.

control unit is wirelessly connected to the reflector and checks its status.[350] A detailed listing of the technical data of the single reflector can be found in Appendix 1.
To assemble the reflectors into a single functional unit, a supporting frame (see Figure 12) is needed, made of an aluminum-magnesium alloy that is highly resistant to corrosion and lightweight.[351]

Figure 12 Supporting frame[352]

As already mentioned, one of the key resources is the roasting drum (see Figure 13, next page). It consists of a stainless-steel roasting basket with augers inside to maximize the rapid coffee mixing and of an aluminum-magnesium alloy support structure. The filling and removal of the coffee is facilitated by a stainless-steel mesh closure with a double opening. The temperature of the roasted beans is measured by a probe located inside the drum. The impeller is driven by a DC motor[353] connected to the impeller itself and fed with low voltage from the photovoltaic (PV) system to achieve maximum energy yield. The low voltage used throughout the system and the lack of connection to the power grid guarantee the operator absolute safety and savings in supply costs.[354] The drum can be placed either outdoors in front of the reflectors -

[350] Cf. PuroSole, 'Solar Coffee Roasting'.

[351] Cf. ibid.

[352] Ibid.

[353] See Glossary.

[354] Cf. PuroSole, 'Solar Coffee Roasting'.

with several tens of meters distance without energy loss because the rays hitting the earth are almost parallel - or inside a building (behind glass).[355]

Figure 13 Roasting drum[356]

The control unit **(**see Figure 14), which is a computer to which different sensors are connected that detect voltages, the acceleration and speed of the drum as well as the temperature of the beans, represents the brain of the system. Even in the case of climate fluctuations, a constant and flawless roasting can be achieved by the control software.[357]

Figure 14 Control unit[358]

[355] Cf. PuroSole, 'Technology'.

[356] PuroSole, 'Solar Coffee Roasting'.

[357] Cf. ibid.

[358] Ibid.

It is important to emphasize that this process of roasting requires fairly constant illumination, which limits the process to days with a clear sky. Each coffee bean must be directly illuminated cyclically and simultaneously from different angles during the process. Beans that are not directly irradiated or are obscured by other beans can remain almost completely raw. Once a roasting process has started, it should not be interrupted.[359]

Advantageously, the potential of solar thermal energy is vast in SSA and the most favorable conditions to address the high-temperature post-harvest processing facilities are provided. The roasting of coffee beans and of other agricultural products is a very promising field. In the tropical region (including all four countries analyzed), the daily average direct normal irradiance ranges from 5.5 to 7.5 kWh/m^2 with annual sunshine of more than 300 days.[360] In comparison, in Germany, it is between about 2.3 and 3.2 kWh/m^2.[361] This great solar potential in SSA can serve as a very profitable advantage for sustainable business models.[362]

Potential key partners for such a business could be coffee beans distributors (e.g. RYO coffee, Coffee Beans Africa), as well as the Circular Coffee Community.[363]

[359] Cf. PuroSole, 'Technology'.

[360] Cf. Majeed et al., 'Solar roaster', p. 3.

[361] Cf. Solargis, 'Irradiation Germany'.

[362] Cf. Majeed et al., 'Solar roaster', p. 3.

[363] Cf. RYO Coffee South Africa, 'RYO Coffee'; Coffee Beans Africa, 'Ag Pro Industries'; Circular Coffee Community, 'Coffee community'.

2.6.2 Solar cooling systems

One of the 17 defined Sustainable Development Goals (SDG), goal 12.3, aims to reduce food loss and waste.[364] As mentioned earlier, the extent of PHL in SSA is also severe, which indicates an urgent need to address this problem with sustainable business model ideas.

One of the problems associated with cold storage is the increased energy requirements and environmental impacts, such as carbon emissions. However, more and more potential solutions are being proposed, including solar energy.[365]

Research on solar technologies such as PV powered cooling systems has shown that the negative impact on the environment is reduced (compared to grid supply-based cooling systems and cooling systems powered by diesel generators), as well as the total system cost based on solar energy. Furthermore, jobs are created through new sustainable business models and access to cold chain services is enabled.[366]

It was found that PHL can be significantly reduced by using solar-powered cold storage.[367] Studies have recognized that through these cooling technologies, inclusive growth can be generated through economic growth and poverty reduction. Either through better functioning of the internal market (including higher and/or more stable prices received by suppliers paired with higher revenues due to lower loss rates), or through their contribution to export growth.[368]

So, advanced refrigeration technologies (including solar-powered cold storage) are increasingly being recognized as a promising tool for addressing the challenges mentioned above.[369] Advantageously, the cost of manufacturing solar power has declined in recent years, increasing the potential economic viability of providing such technologies in poor, mostly rural areas.[370]

A German-based company called GLOBAL ICE TEC AG has recognized these opportunities and is already contributing to this 12.3 SDG by distributing solar-

[364] Cf. ICLEI, ‘Circular food systems’, p. 57.

[365] Cf. Takeshima et al., 'Cold-storages', p. 1.

[366] Cf. Sakiliba and Hassan, ‘Solar PV powered cooling’, p. 1, 5.

[367] Cf. Takeshima et al., 'Cold-storages', p. 14.

[368] Cf. ibid., p. 1.

[369] Cf. ibid.

[370] Cf. ibid., p. 14.

powered refrigerators in SSA, called UNOCOOL, that guarantee 100 % energy self-sufficiency.[371]

GLOBAL ICE TEC AG is present in 21 sub-Saharan countries, including Namibia, Rwanda, Senegal, and Uganda.[372]

Another major environmental benefit of access to refrigeration is the protection of land. Nearly 1.4 billion hectares of land are needed to produce food that is not consumed or nearly 30 percent of the world's agricultural land. Refrigeration allows food to be stored longer and therefore consumed longer. In addition, a benefit of cold storage of food is that it leads to a healthier diet. Moreover, since off-grid areas are often located in rural areas, the introduction of solar-powered appliances will significantly reduce the disparity between urban and rural areas.[373]

Serap, a French-based company, also has a business model based on solar-powered cooling. It develops, produces and sells solar-powered milk cooling tanks for the Rwandan market. This is intended to reduce milk spoilage and thus reduce PHL, especially in areas with limited access to energy.[374]

The company ColdHubs (Nigeria) specializes in stationary solar refrigeration of perishable food. The modular solar-powered walk-in cold rooms (see Figure 15, next page), ColdHubs has developed, can store milk, as well as other perishable food such as fruits, vegetables, meat and fish, in clean plastic crates around the clock. A flat daily fee is paid for each crate stored under a pay-as-you-store subscription model. The cold rooms will be installed in large food production and consumption centers, as well as markets and farms. The production of such a solar-powered cold room requires 120-mm-thick insulating panels to store the cold, and high-power batteries to store the energy from the roof-mounted solar cells. In addition, an inverter is needed to supply the cooling unit with the stored energy. ColdHubs´ partners include the GIZ GmbH, Factor[e] Ventures (a team of impact venture builders dedicated to supporting people and ideas that transform challenges in agriculture, energy, mobility, and waste into de-

[371] Cf. Global Ice Tec AG, ‘Unocool’.

[372] Cf. ibid.

[373] Cf. ibid.

[374] Cf. World Economic Forum, ‘Opportunities for circular economy’, p. 16.

carbonized solutions for emerging and frontier markets) and Fledge (a global network of seed funds and conscious company accelerators).[375]

As mentioned earlier, empowering women is a high priority to increase productivity in SSA. ColdHubs aims to hire primarily women.[376]

Figure 15 Solar-powered walk-in cold rooms[377]

Another company that operates this type of business is the Kenyan company SokoFresh. Its business model features an innovative financing system (pay-as-you-hold) to ensure access. However, the company faces obstacles such as obtaining insurance coverage. The lack of experience of insurance companies with these business models makes it difficult to obtain insurance coverage.[378]

Other companies operating in this field in SSA include InspiraFarms and Cold Solutions Kenya Ltd.[379] Furthermore, the Kenyan company called Twiga Foods is tackling the PHL problem by offering a business-to-business (B2B) e-commerce food supply platform. It sources products from farmers and supplies to vendors through its cold-chain supply system.[380] Its investors include International Finance Corporation, Triodos Investment Management, alphamundi, Index Ventures. Its non-investing

[375] Cf. ColdHubs, 'Solar-powered cold storage'; GIZ, 'Profil'; Factor[e] Ventures, 'Powering impactful technology solutions'; Fledge, 'About'.

[376] Cf. ColdHubs, 'Solar-powered cold storage'.

[377] Ibid.

[378] Cf. World Economic Forum, 'Opportunities for circular economy', p. 16.

[379] Cf. How we made it in Africa, 'Solutions East Africa'.

[380] Cf. World Economic Forum, 'Opportunities for circular economy', p. 17.

partners include the USAID and the German Investment and Development Corporation of KfW.[381]

Although cold storage services are increasing in Africa, they do not meet demand.[382] The companies already mentioned all specialize in food. In SSA, however, there is a need not only for refrigeration of food but also for refrigeration of medicines and vaccines. A study found that refrigerated trucks carrying vaccines need to be introduced in large numbers in SSA to reliably provide the last mile of the vaccination process. Partnerships with vaccine distribution sites are beneficial in this regard.[383]

While mass vaccination against infectious diseases has been carried out in SSA for more than five decades, the cold chain is still poorly developed and highly vulnerable to unforeseen disruptions that can render agents unusable and hamper vaccination campaigns.[384] In the past, there have been numerous incidents where vaccines shipped primarily to SSA have not been adequately (without interruptions) refrigerated or refrigerated at all, rendering them unusable.[385] Therefore, it is of enormous importance to strengthen the cold chain, especially in times of a pandemic.[386]

Vaccination is one of the most cost-effective and successful ways to stop several infectious diseases in Africa and save millions of lives.[387] For instance, chronic viral hepatitis B virus (HBV) affects over 60 million people in SSA. An infant has a 70 % to 90 % chance of developing chronic HBV if infected at birth. So, mother-to-child transmission is a crucial contributor to the ongoing HBV epidemic. Around 20 % of sub-Saharan countries (including Namibia and Senegal) have included the birth dose of the HBV vaccine in their immunization schedule, with an increasing trend. The African Regional Committee of the World Health Organization (WHO) identified the prevention of this virus in children as a priority. The birth dose is the most effective (95 %) prevention measure against mother-to-child transmission when administered within one day after birth and followed by two or three vaccinations. The presence of the vaccine in SSA is not the problem per se; rather, reaching infants born outside of

[381] Cf. Twiga, ‘Investors and partners’; USAID, ‘What we do’; KfW, ‘Afrika’.

[382] Cf. World Economic Forum, ‘Opportunities for circular economy’, p. 16-17.

[383] Cf. Ogwengo, ‘COVID-10 vaccine cold supply chain’, p. 43.

[384] Cf. ibid., p. 42.

[385] Cf. ibid., p. 45-46.

[386] Cf. ibid., p. 42.

[387] Cf. Buitendach et al., ‘Vaccine cooling storage’, p. 36.

health facilities within the short window of time is an everyday challenge. Ensuring the continuity of the cold chain is another major challenge Also, the cost of the vaccine is not a key barrier, as the vaccine is among the cheapest available at 0.20 USD per 10-dose vial.[388]

Targeted implementation efforts that use the latest innovations are needed to ensure timely and effective birth doses, particularly in under-resourced and rural areas that are often difficult to reach.[389]

Countries in SSA are primarily rural, which presents a unique barrier to access. People in SSA who must travel more than two hours to use emergency public medical facilities account for 29 % of the population, with 28 % being women of childbearing age.[390]

Education about the pros and cons of the vaccine plays a critical role as well as the elimination of fears against the vaccination of infants and building trust via personal talks, radio, and social media campaigns. Regarding funding, the international organization Gavi (vaccine alliance), as well as the Baobab Network (invests in African tech entrepreneurs), can serve as potential key partners.[391]

The literature often proposes solutions at the health facility and policy levels. However, Boission et al. suggest that more emphasis should be placed on community-level interventions, especially in very rural areas. One proposed solution would be community health workers who commute between the health facilities and those to be vaccinated in rural communities, to perform home visits and provide, inter alia, vaccinations to infants. Strong communication ties between health facilities and these workers would be crucial. One possible hurdle to overcome would be vaccine refrigeration requirements.[392] A vaccine should be refrigerated at 2 °C to 8 °C.[393]

Transport in particular is often a major challenge. It plays a crucial role in the medical supply chain since patients and medical staff depend on the available transport

[388] Cf. Boisson et al., ‘Birth-dose vaccine in SSA’, p. 1-9.

[389] Cf. ibid., p. 1.

[390] Cf. ibid., p. 10.

[391] Cf. ibid., p. 7, 10; The Baobab Network, ‘Baobab’.

[392] Cf. Boisson et al., ‘Birth-dose vaccine in SSA’, p. 1-6, 10.

[393] Cf. Buitendach et al., ‘Vaccine cooling storage’, p. 36.

system.[394] During such transport, it is important that the cold chain is not interrupted, but the distances are often very long and there is often a lack of access to electricity.[395] Small and portable cool boxes powered by solar energy can be a good option. Such a box is presented by Buitendach et al, who also focus on vaccine cooling and storage. The presented cooling box comprises ten liters of volume holding up to 250 vials of vaccines at a temperature of 2 °C to 8 °C. For this innovation, the following is required: an operator, a user interface, a controller, a cooling holder and a cooling unit, a temperature probe, a solar power system with solar panels, as well as a charge controller and batteries, which serve as energy storage. A 260 W PV panel produces 1.3 kWh of electricity daily. The cooling system requires 1896 Wh of energy daily, leaving a deficit of 596 Wh per day. To operate the cooling system for three days (outside temperature of the cooling box 23 °C) the energy storage must supply the daily deficit of 596 Wh. Thus, the capacity of the energy storage system needs to be at least 1788 Wh.[396]

Since the cool box is very robust and user-friendly, the maintenance costs are also very low and no highly qualified personnel are required to maintain and operate it.[397] These boxes are promising for companies that offer cold transportation solutions.

Global warming and rising demand for temperature-sensitive pharmaceutical goods have led to an increase in the demand for cold transportation solutions. The global market for cold transportation solutions is very promising. Managing transportation alone amounted to over 13 billion USD in 2017 and has a growth rate of around five to six percent.[398]

[394] Cf. Ogwengo, 'COVID-10 vaccine cold supply chain', p. 49.

[395] Cf. Buitendach et al., 'Vaccine cooling storage', p. 36-37.

[396] Cf. ibid., p. 38-44.

[397] Cf. ibid., p. 44.

[398] Cf. Ogwengo, 'COVID-10 vaccine cold supply chain', p. 49-50.

2.6.3 E-Boda-Boda

Most of the African traffic is handled by two- and three-wheeled vehicles that run on gasoline-powered internal combustion engines.[399]

Motorcycles, called Boda-Bodas in East African countries, are an essential mode of transportation throughout the African continent. For instance, in Rwanda, they make up more than half of all vehicles on the roads. Especially in cities crushed by unplanned growth, motorcycle cabs effectively navigate through traffic jams. In East Africa alone, they carry about 100 million people every day. However, in addition to the emissions they cause, they are not cheap to buy, and the fuel they require is expensive.[400]

The company Ampersand, Africa's first and leading company, providing an energy solution for electric motorcycles and transportation, has perceived these problems and created a sustainable solution. This has given the five million motorcyclists in East Africa the opportunity to use commercial, lower-cost electric motorcycles. In 2019, the commercial launch has taken place in Kigali (Rwanda). In 2020, there were about 200 vehicles on the market and five swap stations to exchange batteries.[401]

These e-motorcycles are highly sustainable, emitting 75 % less lifecycle greenhouse emissions than petrol motorcycles using grid power. If all motorcycles in Kigali (approximately 300,000) were electrified, one could save 157,000 tons of CO_2 emissions per year.[402]

Furthermore, e-motorcycles are less time-consuming and far more profitable for consumers than petrol motorcycles. The e-motorcycle is less expensive to purchase, maintain and operate than a fuel vehicle. An Ampersand driver spends only 3.51 USD on fuel per day, whereas a petrol driver spends 4.68 USD on fuel per day. Thus, an Ampersand driver saves 1.17 USD per day. Furthermore, an Ampersand driver makes 3.89 USD profit per day and a petrol driver 2.75 USD per day. Accordingly, the increase in profit for an Ampersand driver is 41 %.[403]

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399 Cf. Bodawerk, ‘Transportation Bodawerk’.

400 Cf. Ampersand, ‘Sustainability Ampersand’; W.L Ntshinga et al., ‘Boda-Boda’, p. 4.

401 Cf. Ampersand, ‘About Ampersand’.

402 Cf. Ampersand, ‘Sustainability Ampersand’.

403 Cf. ibid.

Ampersand's customers are young people.[404] Its partners include FONERWA (an environment and climate change fund, established by the Rwandan government in 2012), USAID, Factor[e] Ventures, Blue Haven Initiative (an innovative family office committed to leveraging assets for competitive returns and positive social and environmental change), Shell Foundation (supports social enterprises that alleviate poverty by improving access to energy and transportation for low-income communities in Africa and Asia), and Startupbootcamp (helps early-stage technology founders rapidly scale their companies through direct access to an international network of key partners, mentors, and investors in their industry).[405]

Ampersand's business model offers both a service and a product, as riders can decide for themselves whether to buy or lease an e-motorcycle. Both are handled via the pay-as-you-drive method.[406] This kind of business is very promising and profitable, especially for low-income drivers.[407]

As soon as the battery needs to be replaced, the driver visits an Ampersand swap station to exchange the used battery for a new one. Payment is made for the energy consumed.[408]

The e-motorcycles´ ultra-high lifecycle lithium batteries have a range of 60 km to 90 km and must be replaced less frequently than drivers typically refuel. They also charge quickly and have passive cooling. Furthermore, every battery has an intelligent battery management system with online telematics[409].[410] As shown in Figure 16 (next page), the battery is located behind the front wheel, quite in the middle of the vehicle and can be easily removed.

[404] Cf. Ampersand, ‘Ampersand’.

[405] Cf. ibid; Fonerwa, ‘Green fund’; Blue Haven Initiative, ‘Investment Blue Haven’; Shell Foundation, ‘Homepage’; Startupbootcamp, ‘About’.

[406] Cf. Ampersand, ‘Technology Ampersand’.

[407] Cf. Ampersand, ‘Sustainability Ampersand’.

[408] Cf. Ampersand, ‘Technology Ampersand’.

[409] See Glossary.

[410] Cf. Ampersand, ‘Technology Ampersand’.

Figure 16 Motorcycle technology[411]

The motorcycles are designed to outperform the established 125cc gasoline motorcycles in terms of power, performance, and durability.[412] The manufacturing of the motorcycles and batteries all takes place locally in Rwanda.[413]

Amper-Ops online and mobile platforms enable on the one hand seamless management of battery packs with customizable parameters (e.g., condition analysis) and on the other hand, insights to understand the ROI of each battery, driver, and swap station. This enables a quick response. In addition, maintenance systems provide indications of necessary repairs and thus prevent failures.[414]

However, Ampersand is not the only successful company in the African market that manufactures and sells e-motorcycles. For instance, the technology company Bodawerk International Ltd., founded by a Ugandan and a German in 2017 and based in Uganda, is also active and successful in this industry. The company develops customized electronics for the needs and environments in SSA, thereby accelerating a sustainable transition to renewable energy.[415]

Its target group is diversified, it includes on the one hand private individuals, farmers, or cab drivers and on the other hand (un-)skilled female and male youths/people from the surrounding area, to provide them with jobs and further training.[416]

[411] Ibid.

[412] Cf. Tech Gist Africa, ‘Rwanda´s boda boda’.

[413] Cf. Ampersand, ‘About Ampersand’.

[414] Cf. Ampersand, ‘Technology Ampersand’.

[415] Cf. Bodawerk, ‘About Bodawerk’.

[416] Cf. ibid.

The partners of Bodawerk International Ltd. include Siemens Foundation, GIZ, Powerhive (develops scalable, bankable off-grid utility solutions), Uganda Investment Authority (UIA) and Partnering for Green Growth and the Global Goals 2030.[417]

The BODAWERK Smart Battery is based on cylindrical lithium-ion cells. With a capacity of up to 4.6 kWh, this battery can carry one up to 100 km on an e-motorcycle.[418] The e-motorcycles have a load capacity of up to 250 kg and can thus transport heavy loads.[419]

As illustrated in Figure 17, the batteries are charged with the help of a solar system.[420]

Figure 17 Solar system charging station[421]

To sum up, in the future, the power of the sun should be used to drive mobility in Africa in an innovative way.

[417] Cf. ibid.

[418] Cf. Bodawerk, 'Energy Bodawerk'.

[419] Cf. Bodawerk, 'Transportation Bodawerk'.

[420] Cf. Bodawerk, 'Agriculture Bodawerk'.

[421] Ibid.

2.6.4 E-Waste

Along with the development and increase of new technologies and the associated boom of the ICT sector, there is also an increase in electronic waste (e-waste) – both by imports of used electronics from the Global North and by domestically produced electronics. From 2014 to 2019, global electronic waste generation increased by 21 %.[422] According to experts, the annually generated e-waste will reach 74.7 metric tons by 2030.[423]

Figure 18 (next page) shows the generated e-waste on the African continent in 2019. As can be seen, Libya is the country where the most e-waste was generated (over 10 kg per capita). Looking at the four countries relevant to this work, one sees that Namibia is the country with the highest generation of e-waste (3-6 kg per capita), followed by Senegal (1-3 kg per capita). Uganda and Rwanda generated almost no e-waste (0-1 kg).

The continent's technological leapfrogging, combined with its fast-growing population and higher disposable income, will lead to an exponential increase in the amount of e-waste generated in Africa. Furthermore, as increasing access to energy has enabled wider acceptance of essential electrical products (including solar energy products), the life cycle of these products is becoming shorter as producers use less durable and valuable components to make the products more affordable.[424]

[422] Cf. Maes and Preston-Whyte, ‘E-waste lessons’; World Economic Forum, ‘Opportunities for circular economy’, p. 29.

[423] Cf. World Economic Forum, ‘Dealing with e-waste’.

[424] Cf. Leacock, ‘E-waste value chain’.

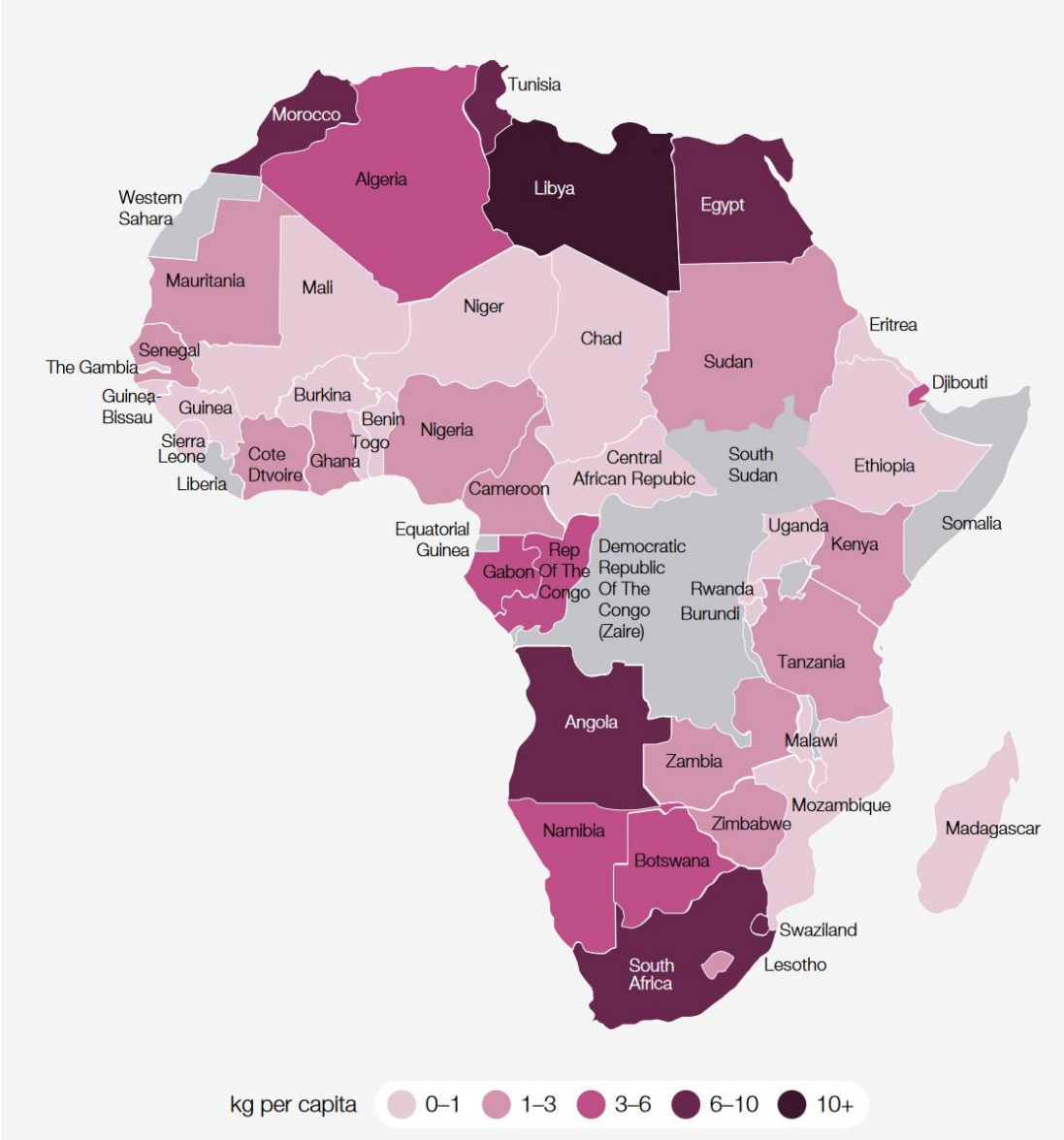


Figure 18 Generated e-waste in Africa (2019)[425]

However, African countries are pioneering efforts to reduce e-waste by adopting policies, regulations and laws (including extended producer responsibility). These countries include Cameroon, Kenya, Rwanda, Tanzania, Uganda, Egypt, Madagascar, South Tome and Principe, South Africa, Zambia, Cote d´Ivoire, Ghana, and Nigeria.[426] The African informal sector, including recyclers and collectors, dominates e-waste management. There is no organized take-back system or regulations for sorting and

[425] World Economic Forum, 'Opportunities for circular economy', p. 28.

[426] Cf. Lebbie et al., 'Serious threat', p. 12.

dismantling. E-waste is often processed in small junk shops or scrapyards. Open dumps are also often the place of action.[427]

One of the African pioneering e-waste organizations is WEEE Centre (Kenya).[428] Another pioneering recycling center in East Africa is Enviroserve.[429] Other potential key partners for e-waste businesses could be GOGLA, the global association for the off-grid solar energy industry, and Close the Gap, an international social enterprise that offers high-quality used computers donated by European and international companies for educational, medical and social projects in developing and emerging countries.[430]

In addition to preventing damage to health through proper recycling, the recovery of expensive and scarce materials (e.g. iron, gold, and copper) from e-waste through collection and recycling represents a great opportunity for the economy. The value of raw materials in Africa's e-waste is about 3.2 billion USD.[431] Recycling these materials is more economically and environmentally profitable (e.g. requires much less energy and counteracts the scarcity of natural resources) than extracting natural resources from the ground.[432]

Other benefits include a positive image of the brand.[433] In general, consumers become more environmentally conscious and increase pressure on industries to become more sustainable.[434] There are already significant circular economy solutions for improved electronic waste management in the electronics sector.[435] Some (few) companies have already recognized and seized the opportunities of e-waste recycling. The promising business idea of one of these companies is explained in more detail below.

[427] Cf. World Economic Forum, 'Opportunities for circular economy', p. 30.

[428] Cf. ibid.

[429] Cf. Enviroserve, 'E-waste management'.

[430] Cf. GOGLA, 'About'; Close the Gap, 'Sustainable recycling'.

[431] Cf. World Economic Forum, 'Opportunities for circular economy', p. 31.

[432] Cf. Leacock, 'E-waste value chain'.

[433] Cf. Global LEAP Awards, 'E-waste management', p. 2.

[434] Cf. World Economic Forum, 'Opportunities for circular economy', p. 33.

[435] Cf. ibid., p. 7.

Power banks and flashlights

Bodawerk International Ltd. (Uganda) already makes use of the African waste produced. The company uses old lithium-ion cells from broken power tools, laptops, and other devices to produce and sell flashlights and power banks with integrated flashlights (see Figure 19). So far, two different power banks and a flashlight are sold. One is for 99,000 Ugandan Shilling (UGX), which has a capacity of 15,000 milliampere-hour (mAh; unit of electric charge) and provides up to 15 hours of charging time and 300 hours of light from two built-in flashlights. And the other is a power bank for 69,000 UGX with a capacity of 10,000 mAh that provides up to 10 hours of charging and 240 hours of light from one built-in flashlight. Offered for 39,000 UGX, the light-emitting diode (LED) flashlight with a 2,500 mAh battery capacity can shine for up to 20 hours or charge a device via the built-in USB output. All products are charged via USB.[436]

In addition to the sales model, a leasing model would also be a viable option. The social enterprise WeTu (Kenya) has already seized this opportunity and focuses on leasing solar lights to fishermen in the shore areas of Lake Victoria.[437]

Figure 19 E-waste power bank[438]

[436] Cf. Bodawerk, 'Recycling Bodawerk'.

[437] Cf. Global LEAP Awards, 'E-waste management', p. 23.

[438] Bodawerk, 'Recycling Bodawerk'.

The production costs of an e-waste solar power bank with an integrated flashlight that is outperforming Bodawerks model with a capacity of 20,000 mAh, can be calculated using the widespread 18650 battery format. This cell type is used worldwide in laptop batteries and power tools. A common model for this format is the Panasonic NCR18650B-3 lithium-ion cell, which has a measured capacity of 11.33 Wh.[439]
Assuming a degradation of 20 % of its capacity through prior use results in a remaining capacity of 9.064 Wh/cell. The amount of energy stored in a 20,000 mAh power bank is $20\ Ah * 3.6\ V = 72\ Wh$. Therefore, the number of cells needed for one power bank is $\frac{72\ Wh}{9.064\ Wh/cell} = 7.94\ cells\ \rightarrow 8\ cells$. Assuming the price for one e-waste cell after testing and sorting is 1.50 EUR/cell, the total cost for battery cells for one power bank is $8\ cells * 1.50 \frac{EUR}{cell} = 12\ EUR$. With assumed costs for the housing, charging electronics, LED, e-waste solar cell, production, and packaging at 11 EUR, the estimated total production costs per e-waste solar power bank with an integrated flashlight are 23 EUR.
Using two of the same Panasonic NCR18650B-3 lithium-ion cells, a LED flashlight with a capacity of $\frac{2*9.064\ Wh}{3.6\ V} = 5.035\ Ah = 5{,}035\ mAh$ can be produced, outperforming the model of Bodawerk capacity-wise more than twice. Assuming a price of 1.50 EUR/cell, and 5 EUR for the housing, charging electronics, LED, production and packaging the total production cost for one e-waste flashlight is 8 EUR. This business idea not only addresses the problem of e-waste but also provides affordable access to power and light.

E-waste energy storage

As the country analysis showed, access to electricity is a common problem in SSA. However, through the analysis it was also found that 91 % of micro, small and medium enterprise respondents to the Productive Use of Electricity program already use solar energy and own the panels, showing that PV is becoming increasingly important for energy supply in rural SSA.[440] To make use of solar power not only during the day but also at night, battery-powered energy storage systems based on lithium-ion technology

[439] Cf. Muenzel et al., 'Testing study', A1592.

[440] Cf. Charles et al., 'Energy storage SSA', p. 1207.

can be used. Thus, companies/households can (fully) supply themselves with solar power around the clock, independent of the grid.

For these systems, the cost of batteries accounts for 81 % to 93 % of the total storage system costs.[441] Therefore, the effect of cost-efficient e-waste battery cells becomes advantageous.

On average, the overnight energy usage of a sub-Saharan household in a remote area is about 1.42 kWh.[442] A suitable battery pack for this kind of household should offer a capacity of about 2,000 Wh. As mentioned above, a commonly found lithium-ion cell is the Panasonic NCR18650B-3. Using this type of battery, the needed number of e-waste cells is $\frac{2{,}000\ Wh}{9.064\ Wh/cell} = 220.65\ cells \rightarrow 221\ cells$, resulting in assumed costs of $221\ cells * 1.50 \frac{EUR}{cell} = 331.50\ EUR$. Considering additional given costs of 127.84 EUR for a charge controller and assumed costs of 100 EUR for the housing, cables, production and packaging, the total production costs could be as low as 559.34 EUR.[443]

Considering these facts, the sustainable opportunities offered by (renewable) energy in combination with the potentials of the four countries studied should be used by households to become more independent in electricity supply and by enterprises to gain competitive advantages and strengthen the economy in SSA through the driving force of energy.

[441] Cf. ibid., p. 1211.

[442] Cf. ibid., p. 1210.

[443] Cf. ibid., p. 1212.

2.7 Productive use through ICT

The African continent is catching up decades within a few years and in many different sectors. Entire stages and hurdles in a development process are simply skipped. For instance, Africa is leapfrogging the era of checks and passbooks. Mobile money- a service that allows people to send and receive money by cell phone - is coming into use instead. Today, nearly half of all global users of mobile money are found in SSA. In 2020, 64 % of all global mobile transactions took place in Africa. Furthermore, for example, no retail chains mean an e-commerce boom. Or no large cab companies mean more space and better opportunities for online intermediary services for passenger transportation.[444]

ICTs play an important role in this respect and open up promising opportunities for the African market. But what opportunities are exactly created due to leapfrogging favored by ICT? Some opportunities are now explained. These include e-commerce and logistics services.

2.7.1 E-commerce

E-commerce has great potential in developing countries. Household consumption can be enhanced, and inequalities can be reduced by providing people, for instance in rural areas, with the variety, convenience, and low prices that urban residents already enjoy. Thus, e-commerce can contribute to economic growth by reducing information asymmetry and increasing economic efficiency. Furthermore, it can be an effective tool for job creation for semi-skilled workers, women, and youth.[445]

In particular, for the growing middle class in Africa, the e-commerce market is creating a new kind of shopping experience.[446]

A report by the United Nations Conference on Trade and Development shows that there were at least 21 million online shoppers in Africa in 2017, which represents less than 2 % of the global total. Positively noted, the number of online shoppers has been increasing by 18 % per year since 2014, 6 % more than the average growth rate globally. However, nearly 50 % of these 21 million online shoppers were in the three

[444] Cf. Bogner and Hertzberg, 'Afrikanischer Traum', p. 26.

[445] Cf. The World Bank Group, 'E-Commerce'.

[446] Cf. Odonkor, 'E-commerce Africa'.

countries of South Africa, Nigeria, and Kenya.[447] This points out that especially in other African countries such as Namibia, Rwanda, Senegal, and Uganda, online purchases still need to be pushed and the potential needs to be exploited.
As the country analysis shows, Internet use is increasing in all four countries. In fact, the number of online shoppers will increase when the number of Internet users increases.

Furthermore, several points strengthen the potential of the e-commerce market in general, and on the African continent:

- Those born after 1995, also known as Generation Z, are growing up with language as an interface and artificial intelligence and are embracing innovation faster than any previous generation. Generation Z identifies with brands and is connected and accessible via social media platforms such as Instagram, TikTok, or YouTube. E-commerce has become indispensable.[448]
- The fastest growing mobile market worldwide is found in Africa (average growth of 30 % in mobile penetration since 2000).[449]
- The continent is home to the second most connected population after Asia.[450]
- According to forecasts by the McKinsey Global Institute, e-commerce could account for 10 % of total retail sales in Africa's largest economies by 2025, equivalent to 75 USD billion in online sales per year.[451]
- By 2030, one in five of the world´s consumers will be on the African continent.[452]
- Climate neutrality is an important hygiene factor in e-commerce.[453]

But what types of e-commerce business models exist that could be considered for the African market?

[447] Cf. United Nations, ‘B2C E-commerce’, p. 15.

[448] Cf. Heinemann, 'Online-Handel', p. 11.

[449] Cf. Odonkor, ‘E-commerce Africa’.

[450] Cf. ibid.

[451] Cf. ibid.

[452] Cf. ibid.

[453] Cf. Heinemann, 'Online-Handel', p. 13.

E-commerce with fashion in Africa, for example, has already grown significantly in recent years. In the process, sales have doubled every two years since 2017 to a total of over 8 billion USD, which is very promising. By 2025, this amount is estimated at 12 249 million USD.[454]

Sarah Diouf, Senegal´s most famous fabric designer, is convinced that African patterns will become mainstream. In addition, through the Black Lives Matter movement, black-owned businesses are benefiting. Just like Sarah´s business, which stands for fashion conceived by Africans and made by Africans. In short, African fashion is becoming an attitude to attract. Already today H&M cooperates with an African label and IKEA designed furniture with African artists. Additionally, online stores like Asos already sell African fashion, and the department store chain Bloomingdale advertises with the slogan, "Africa, your time is now".[455]

Famous African influencers could also serve as potential key partners for e-commerce with fashion. These are, for instance, Khaby Lame (Senegal), Onyi Moss (Nigeria), Sarah Langa (South Africa).[456]

However, up to 80 % of all Africans wear second-hand clothes.[457] As a consequence of fast fashion, there has been a large influx of second-hand clothing in Africa. Kantamanto Market (Ghana) is home to one of the largest secondhand markets in Africa. However, around 50 metric tons of unsold second-hand clothing are thrown away every single day (40 % of all imported second-hand clothing).[458] There is an urgent need to discourage the throwing away of old clothes to avoid environmental damage. Sustainable business models can serve as one solution.

One of the innovative business models that have already developed in the course of the sustainability discussion is from the field of **re-commerce** (r stands for re-use and e for electronic), that is the buying and selling of used items or second-hand articles. Both the growth rates and the dynamics in re-commerce are large and promising. Re-commerce not only enables price advantages and a larger customer base, but also an ecologically sustainable way of life that counteracts climate change. Furthermore,

[454] Cf. Bogner and Hertzberg, 'Zeit', p. 23-29.

[455] Cf. ibid.

[456] Cf. Kühl, 'Khaby Lame'; Fashion Monitor, 'Onyi Moss'; Jabulani, 'Sarah Langa'.

[457] Cf. Bogner and Hertzberg, 'Zeit', p. 23-27.

[458] Cf. World Economic Forum, 'Opportunities for circular economy', p. 33.

experts believe that the potential of second-hand trade is enormous.[459] Advantageously, second-hand trends are already developing in Africa through local designers and tailors. Africa is at the forefront of the emerging circular fashion industry as momentum continues to build on the ground.[460]

Applying a circular economy approach to the existing fashion industry could generate new initiatives that recycle and upcycle garments. As a positive side effect, new jobs will be created.[461]

One way to implement a re-commerce business idea is with the help of a progressive web app, which is highly likely to replace consumer-facing native apps in the coming years and will be a game changer for e-commerce. A progressive web app is a hybrid of a native app and a website and is designed in such a way that websites can be installed as apps so that native apps are no longer needed.[462] Voice search[463] could serve as a special feature as an alternative shopping option, which is becoming increasingly important.[464]

[459] Cf. Heinemann, 'Online-Handel', p. 14-15.

[460] Cf. World Economic Forum, ‘Opportunities for circular economy’, p. 33.

[461] Cf. ibid., p. 35.

[462] Cf. Heinemann, 'Online-Handel', p. 15, 29.

[463] See Glossary.

[464] Cf. Heinemann, 'Online-Handel', p. 19-20.

2.7.2 Logistics services

Nowhere is the transport of goods as expensive as in Africa. Transport costs account for 6 % to 7 % of the price of goods in Europe and the USA, compared with up to 70 % in Africa, caused by poor infrastructure, closed borders, congestions, lack of credit, poor organization, corruption, theft, and the climate. Such inefficient African logistics make the goods produced more expensive, so they cannot compete globally.[465]

According to logistics experts, now is the age of the so-called "Delivery Economy". This involves the collective expectation of customers that ordered products will be delivered as quickly, cheaply, and completely transparently as possible. Delivery is therefore the core success factor of online retailing.[466]

However, to meet customers´ rising demand for shorter delivery times, shipments must be more frequent and smaller, resulting in fewer than full truck loads.[467] As mentioned in the chapter above, e-commerce is growing and as e-commerce grows, so does the demand for delivery services but these services are often executed by small vehicles such as motorcycles that transport less.[468]

Furthermore, errors often occur in the last mile due to incomplete addresses of still unnamed rural roads. This challenge leads to delays, inefficiencies, increased communication costs, and reverse logistics in urban and rural areas.[469] Here, ICT can be used to reduce tensions in the value chain and develop innovative sustainable business models.

For instance, e-logistics platforms can facilitate delivery services.[470] In addition to existing e-logistics platforms in SSA, crowd-logistics services for last-mile deliveries[471] and city distribution can be a promising concept.[472]

Crowd logistics involves delivery operations by encouraging passengers to use their spare transportation capacity in planes, buses, cars, or (motor) bicycles on trips already

[465] Cf. Bogner and Hertzberg, 'Problemlösung', p. 21.

[466] Cf. Heinemann, 'Online-Handel', p. 39-40.

[467] Cf. Agyemang, 'Sustainable crowd logistics', p. 751.

[468] Cf. Boateng et al., 'Digitization', p. 192.

[469] Cf. Alharbi et al., 'Crowd Models', p. 2, 10; Heinemann, 'Online-Handel', p. 39-41.

[470] Cf. Boateng et al., 'Digitization', p. 199.

[471] See Glossary.

[472] Cf. Buldeo Rai et al., 'Crowd logistics', p. 7.

taking place to carry packages for others.[473] For example, it can allow commuters who use public transportation to transport packages for others without having to be drivers.[474] In addition to the transportation of packages, passenger transportation can also be identified as a type of crowd logistics service.[475]

In general, the crowd can be divided into three categories: casual drivers (e.g., freelancers, commuters, students, or retirees), professional drivers, who are employed by courier businesses, and subcontractors, who are working for mainstream brands but dispose of free capacity.[476]

Crowd logistics is part of the global sharing economy trend. According to a survey instructed by the European Commission, most likely users of sharing economy platforms are highly educated and younger people, living in urban areas.[477] This kind of service is done through mobile apps and collaborative platforms that connect individuals and firms to peers.[478]

While urban freight transport contributes to the competitiveness of the industry, as well as to wealth-creating activities, it also causes negative social, economic, and environmental impacts, such as traffic congestion and air pollution. [479]

Whether transporting passengers or packages, crowd logistics leads to social, economic, and in particular environmental benefits. For instance, these benefits are maximization of logistics efficiency, support of communities, reduced emissions, traffic, and resources.[480]

An African study has shown that people's transportation choices are crucial for the sustainability of crowd logistics.[481] In countries like Rwanda, environmentally friendly transport is already being promoted, according to the country analysis.

Location sharing and real-time tracking through crowd delivery provide transparency and benefits to people in urban and rural areas, solve address problems, and lead to

[473] Cf. ibid., p. 1-3.

[474] Cf. ibid., p. 5-6.

[475] Cf. Alharbi et al., ‘Crowd Models’, p. 3.

[476] Cf. Buldeo Rai et al., ‘Crowd logistics’, p. 7.

[477] Cf. ibid., p. 2.

[478] Cf. Zalia et al., ‘Crowd Logistics´ impact’, p. 419.

[479] Cf. Buldeo Rai et al., ‘Crowd logistics’, p. 1-3.

[480] Cf. ibid.

[481] Cf. Zalia et al., ‘Crowd Logistics´ impact’, p. 431-432.

increased levels of trust.[482] Furthermore, crowd logistics offers next to consumers access to a wider range of products (mail, food, electronics, etc.), a more personal, convenient, flexible, faster, and traceable real-time delivery service. The crowd is motivated by supplementary earning opportunities that are adaptable and individualized to their lifestyle.[483]

Additionally, the number of errors occurring in the last mile can be reduced because citizens are more flexible and better connected than traditional logistics providers. [484] According to the United Nations, in emerging markets where same-day delivery is an option, nearly four billion people live in areas without street numbers or names. Thus, one of the challenges for logistics in African regions is delivery to incomplete addresses. These address problems lead to delays, inefficiencies, increased communication costs, and an increase in reverse logistics for last-mile delivery in both urban and rural areas. Here, crowd logistics can serve as a solution.[485]

But what is crucial for this kind of logistics to work well?

First and foremost, technological infrastructure in the form of an accessible platform is crucial for coordinating the supply and demand of logistics services.[486] Additionally, the social factor of population density also plays an important role in the development of crowd logistics. The increasing population density in cities has laid the foundation for a critical mass that forms the backbone of crowd logistics platforms.[487]

Furthermore, crowd logistics presuppose free capacities in the form of volume but also time. Since crowd logistics rely heavily on people with a high degree of flexibility, bringing in professional third parties is one way to ensure tasks are completed promptly. Moreover, the network is crucial.[488] There are several channels to reach the network. The social enterprise WeTu (Kenya) found that bulk SMS (0.02 USD per

[482] Cf. Alharbi et al., 'Crowd Models', p. 11.

[483] Cf. Buldeo Rai et al., 'Crowd logistics', p. 1-3.

[484] Cf. ibid.

[485] Cf. Alharbi et al., 'Crowd Models', p. 3, 5.

[486] Cf. Buldeo Rai et al., 'Crowd logistics', p. 5.

[487] Cf. City Logistics, 'Last mile delivery'.

[488] Cf. Buldeo Rai et al., 'Crowd logistics', p. 5-6.

message), followed by radio, is the most effective channel to reach a certain mass and draw attention to services.[489]

Regarding revenue, it was found that a membership-based revenue model is the most profitable.[490]

The biggest barriers regarding profitable crowd logistics are uncertainties such as the increased risk of theft, loss, damage, and privacy concerns. To counteract this, feedback systems and secure online payment systems can be used as mechanisms.[491] Also, many businesses have implemented robust courier selection processes to build trust.[492] Another solution to respond to these uncertainties can be derived from an example of an African logistics entrepreneur: in an interview, the entrepreneur explained that his second biggest cost was theft. After a while, he noticed from his observations that all the problems had a common denominator: men. As a result, he started a company run and executed by women and was pleasantly surprised in every way. Since then, nothing is stolen anymore, there are no more major accidents, and the freight arrives on time.[493]

Considering partnerships, IT specialists, retailers, and investors can be identified as key partners.[494]

In Africa, there is a large gap in available crowd logistics platforms for businesses, although Africa has a huge market potential for these platforms.[495] A study in Ghana found that people are willing to accept the concept of crowd logistics and participate in its implementation despite the obstacles such as low IT consumption, transportation means or economic system.[496]

[489] Cf. Global LEAP Awards, 'E-waste management', p. 28.

[490] Cf. Buldeo Rai et al., 'Crowd logistics', p. 6.

[491] Cf. ibid., p. 6-7.

[492] Cf. Zalia et al., 'Crowd Logistics´ impact', p. 420.

[493] Cf. Bogner and Hertzberg, 'Liter', p. 103.

[494] Cf. Buldeo Rai et al., 'Crowd logistics', p. 7.

[495] Cf. Agyemang, 'Sustainable crowd logistics', p. 754-755.

[496] Cf. Zalia et al., 'Crowd Logistics´ impact', p. 432.

3 Identification and evaluation of ten sustainable business model ideas

Given the literature review, it appears that the four countries studied face similar problems, such as dependence on rain-fed subsistence agriculture and lack of access to electricity. However, the analysis also shows that each country has great potential in different areas, such as the renewable energy sector or the ICT sector. Additionally, it emerges that natural resources, energy, and ICT can create productive use that promotes economic growth and reduces poverty. On this basis, ten promising business model ideas (see Figure 20-29, page 93-102) that tap the potentials and address the problems can be identified and presented in the circular BMC framework already developed in chapter 2.3.

Since it is often difficult to pursue and successfully implement all ideas with equal weighting, it is necessary to prioritize the ideas by evaluating them.[497] Therefore, these identified ideas are subsequently evaluated by experts. The thirteen evaluation criteria established can be seen in Table 1 (next page).

Table 1 shows the assessment table of the ten business model ideas filled in by each expert. Using a 5-point grid (1= very negative, 2= negative, 3= moderate, 4= positive, 5= very positive), each business model idea is rated.

If access to the required resources is extremely easy/unlimited, the idea is rated a 5. A decreasing number (towards 1) indicates lower levels of access.

If extremely little capital and know-how is required to implement a business model idea and the complexity of the technology required for this is extremely low and there are no external restrictions, the idea is also rated with a 5.

A decrease in the number (towards 1) in these cases indicates an increase in the required capital, know-how as well as a higher complexity of the technology and an increase in external restrictions.

An extremely large benefit is also assigned a 5. The smaller the benefit, the lower the number to be assigned.

The more comprehensive the circular economy is covered by the idea and the higher the benefit, the higher it is rated. The more the idea is based on the use of renewable sources, the higher the number to be assigned.

[497] Cf. Schallmo, 'Geschäftsmodelle', p. 118.

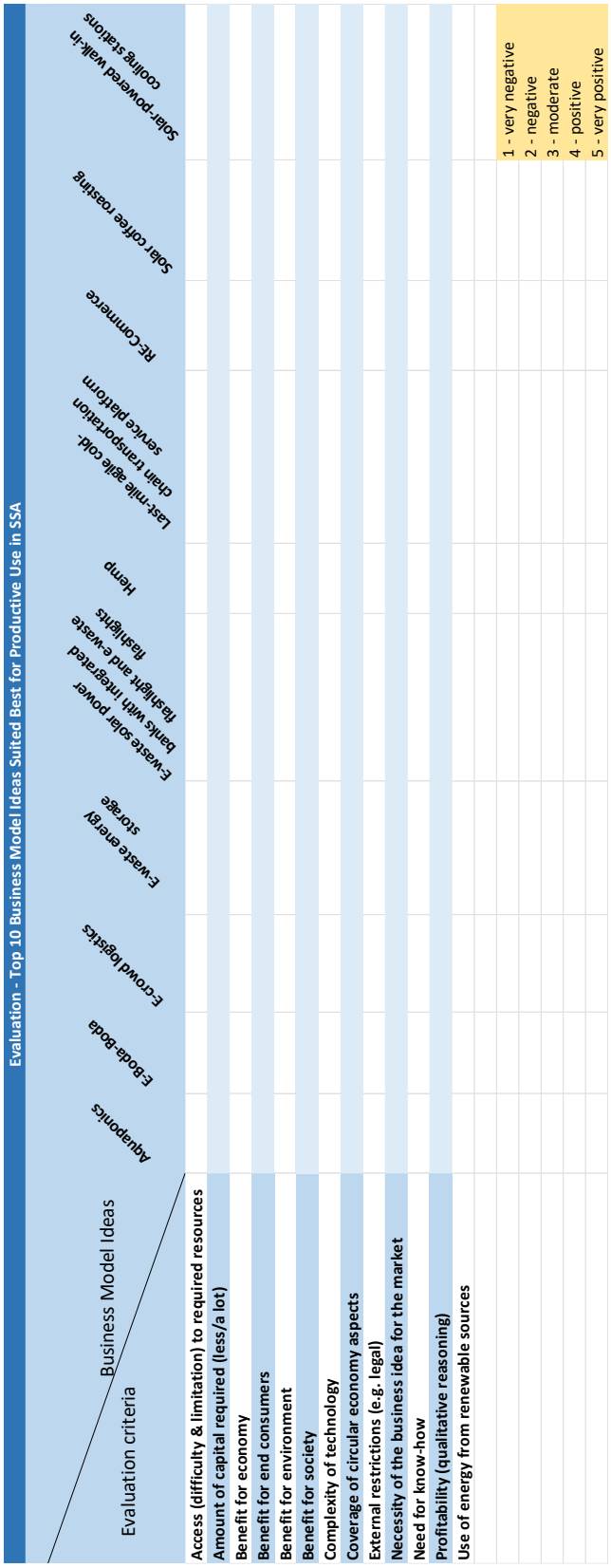


Table 1 Assessment table[498]

[498] Own illustration.

As already mentioned in the methodology, the ranking of the ideas is performed using fuzzy logic with artificial intelligence, based on the system for exploring country risks (CRISK-Explorer) for larger and smaller emerging market countries proposed by Steurer. The ranking list created in Microsoft Excel can be found in the digital appendix of this thesis (see Appendix 3). Screenshots of the detailed assessments of the business model ideas by the individual experts as well as the derivation of the individual ranking can be found in Appendix 2.

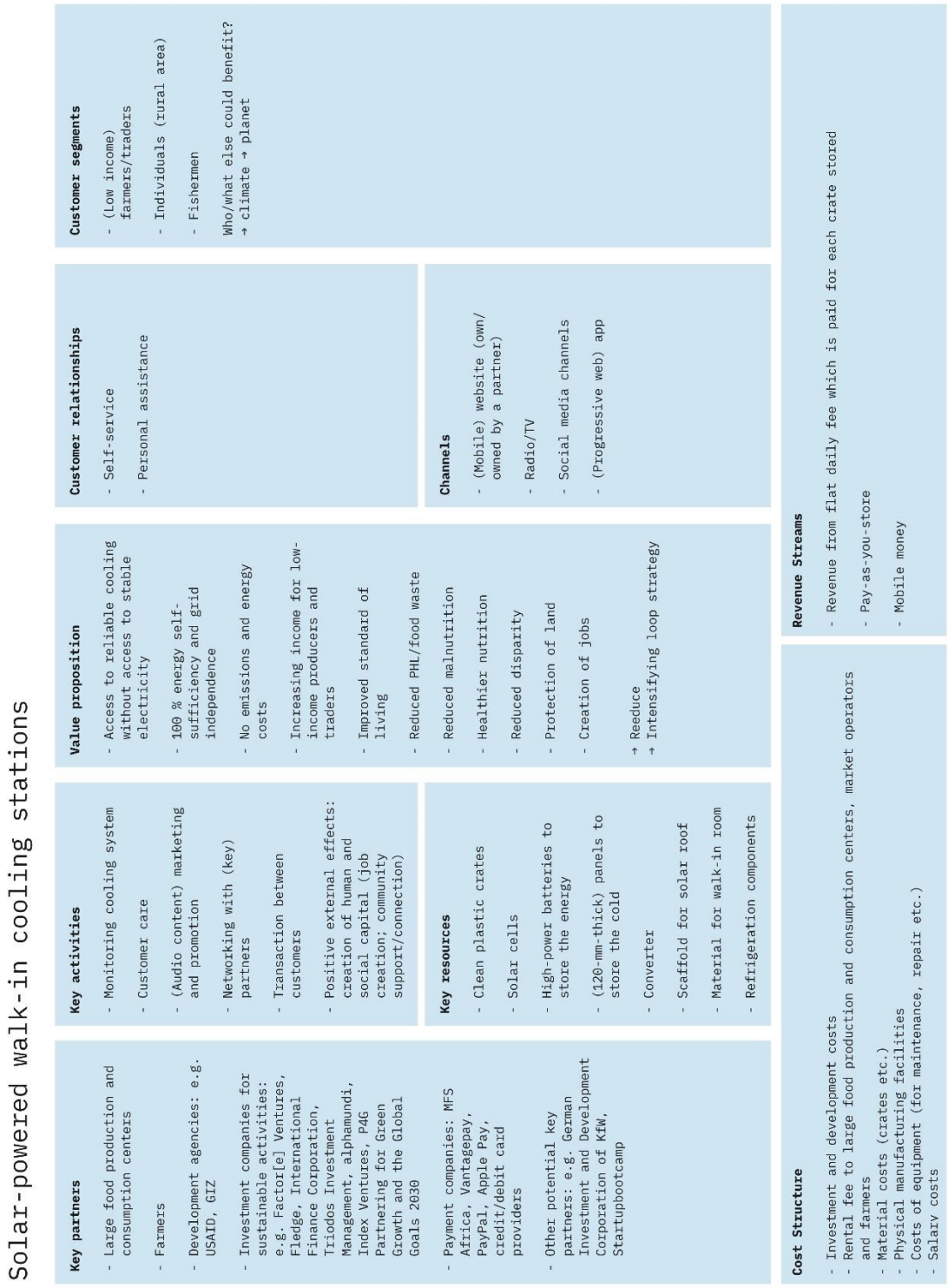


Figure 20 Circular BMC: solar-powered walk-in cooling stations[499]

[499] Own illustration, based on Osterwalder and Pigneur, 'Business Model Generation', p. 44.

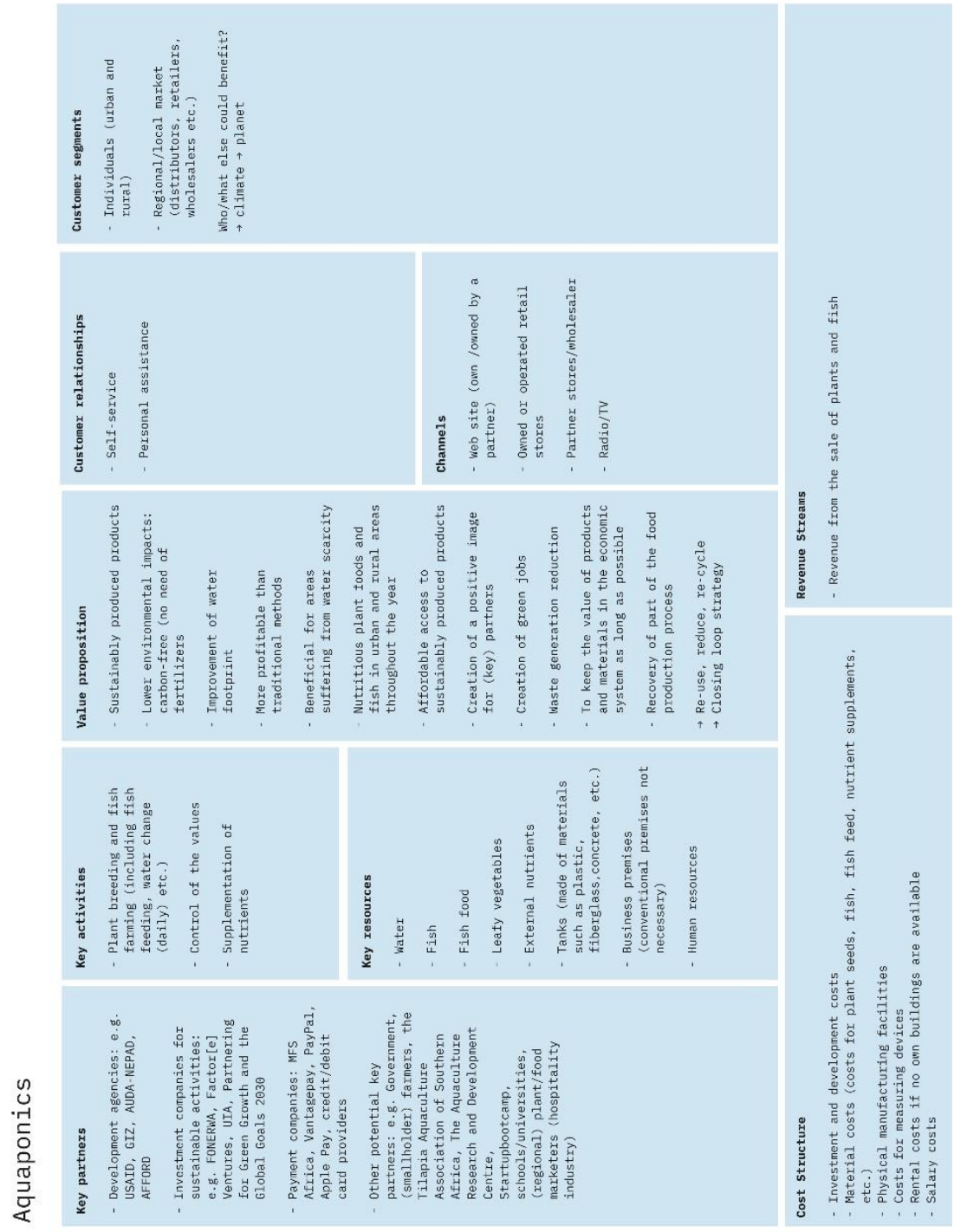


Figure 21 Circular BMC: aquaponics[500]

[500] Own illustration, based on ibid., p. 44.

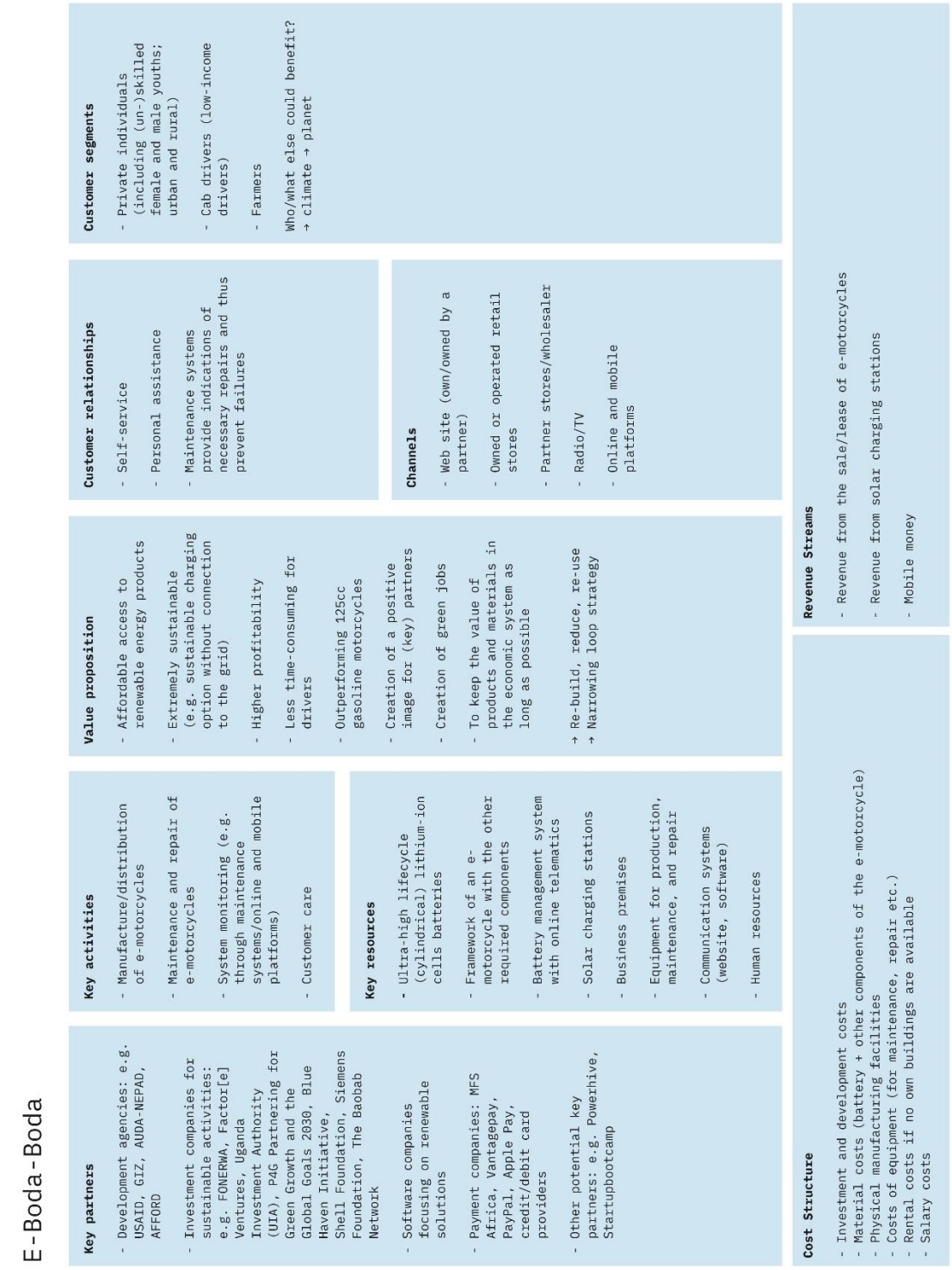


Figure 22 Circular BMC: e-Boda-Boda[501]

[501] Own illustration, based on ibid.

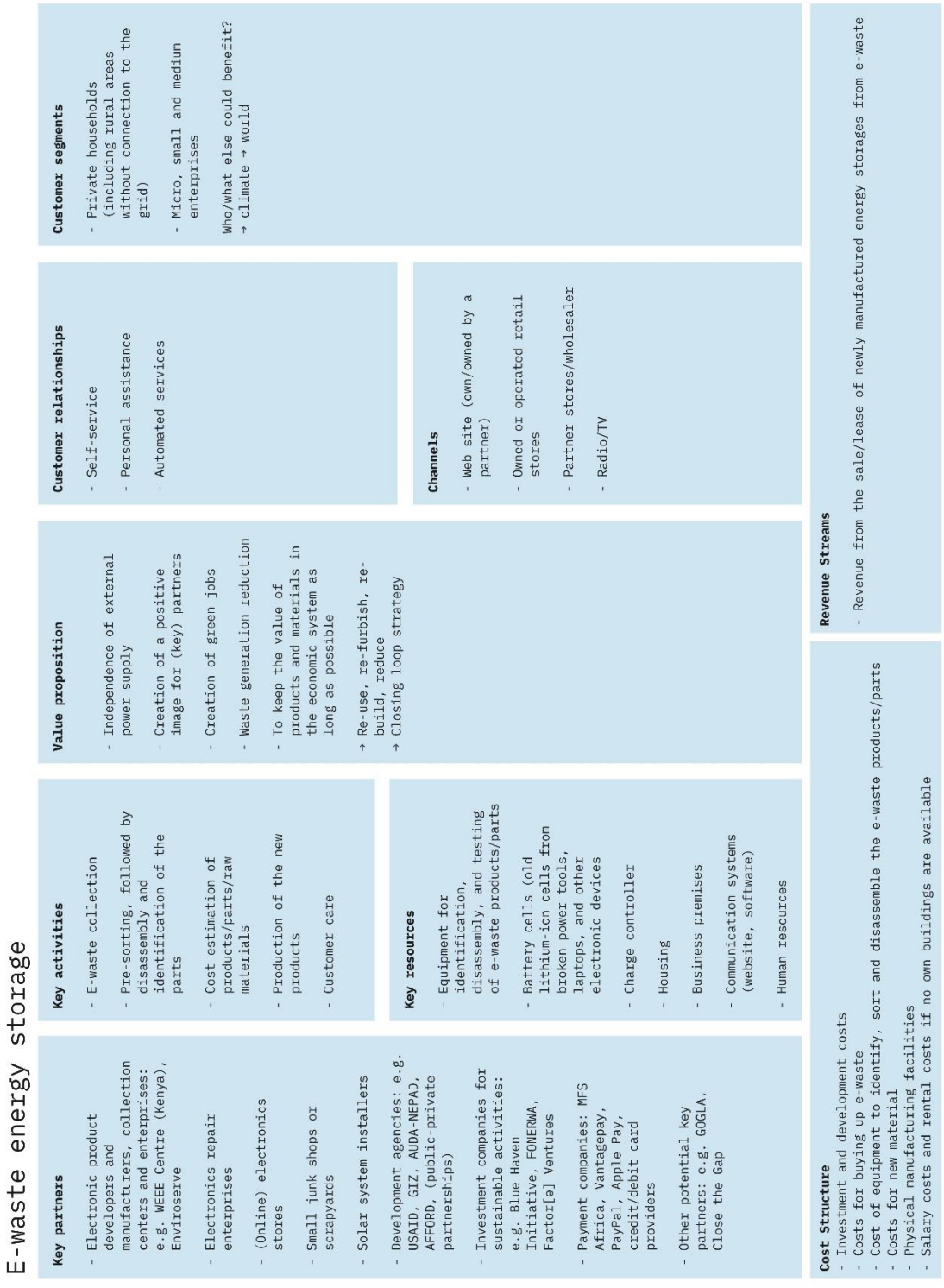


Figure 23 Circular BMC: e-waste energy storage[502]

[502] Own illustration, based on ibid.

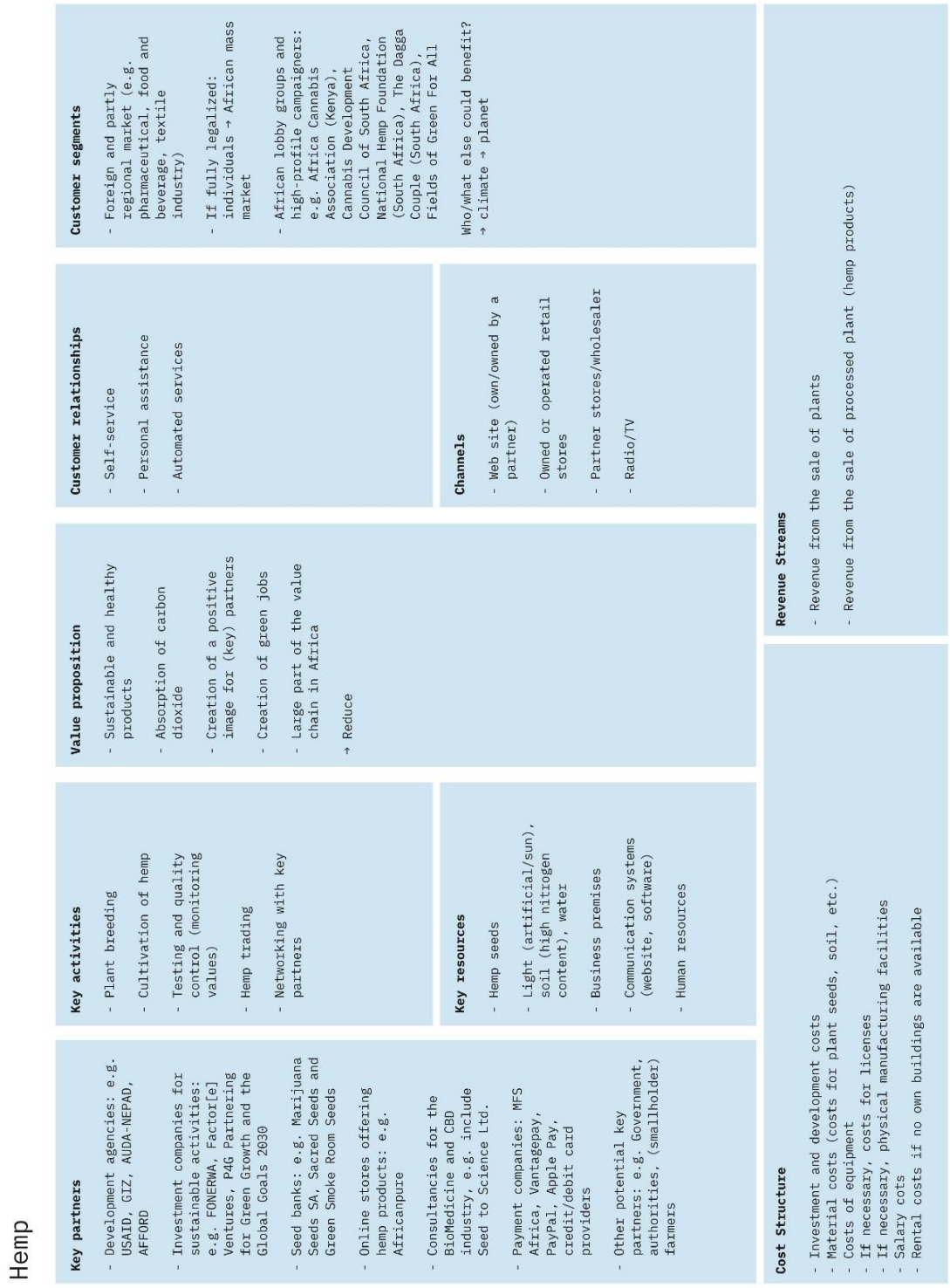


Figure 24 Circular BMC: hemp[503]

[503] Own illustration, based on ibid.

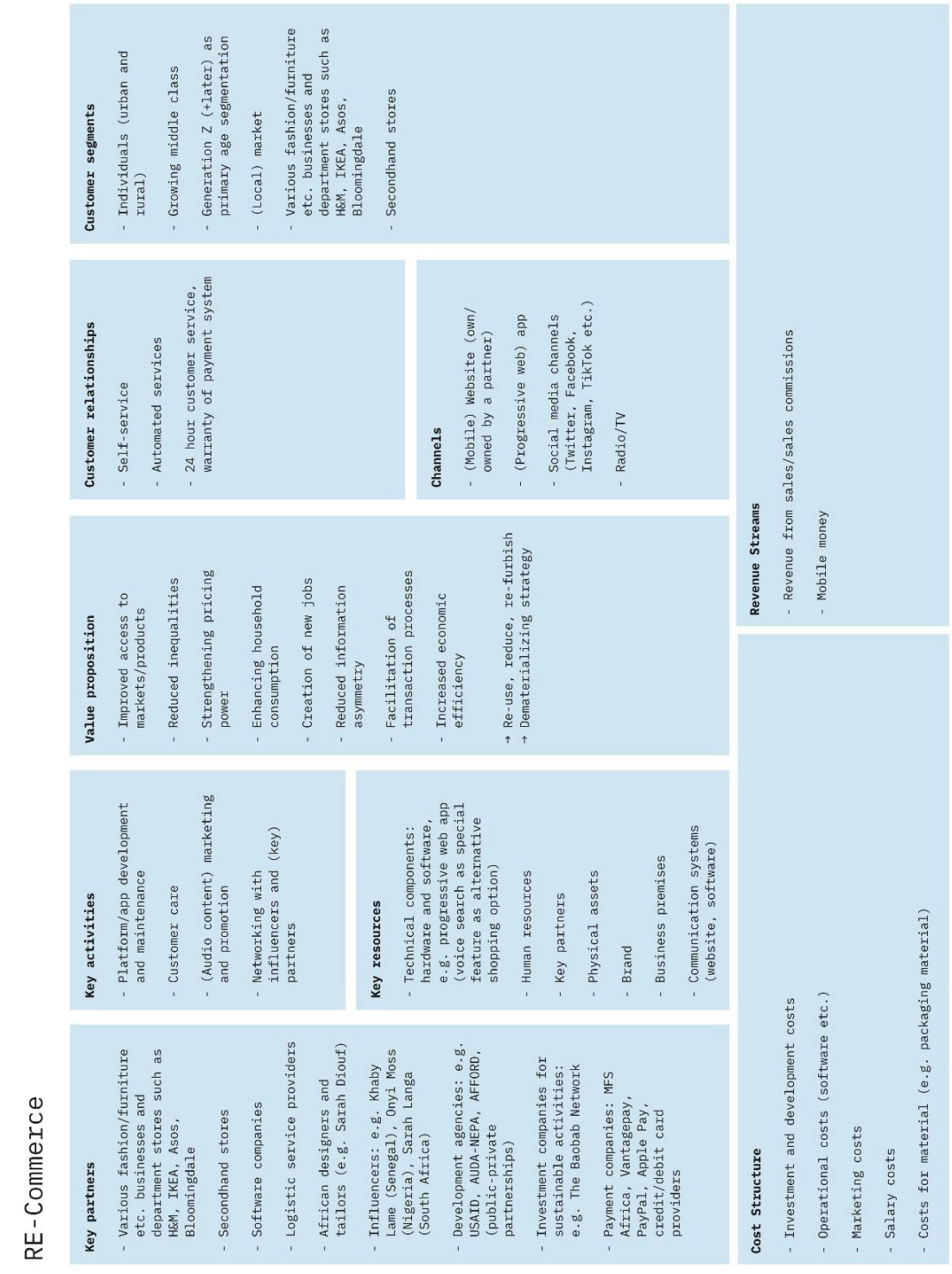


Figure 25 Circular BMC: re-commerce[504]

[504] Own illustration, based on ibid.

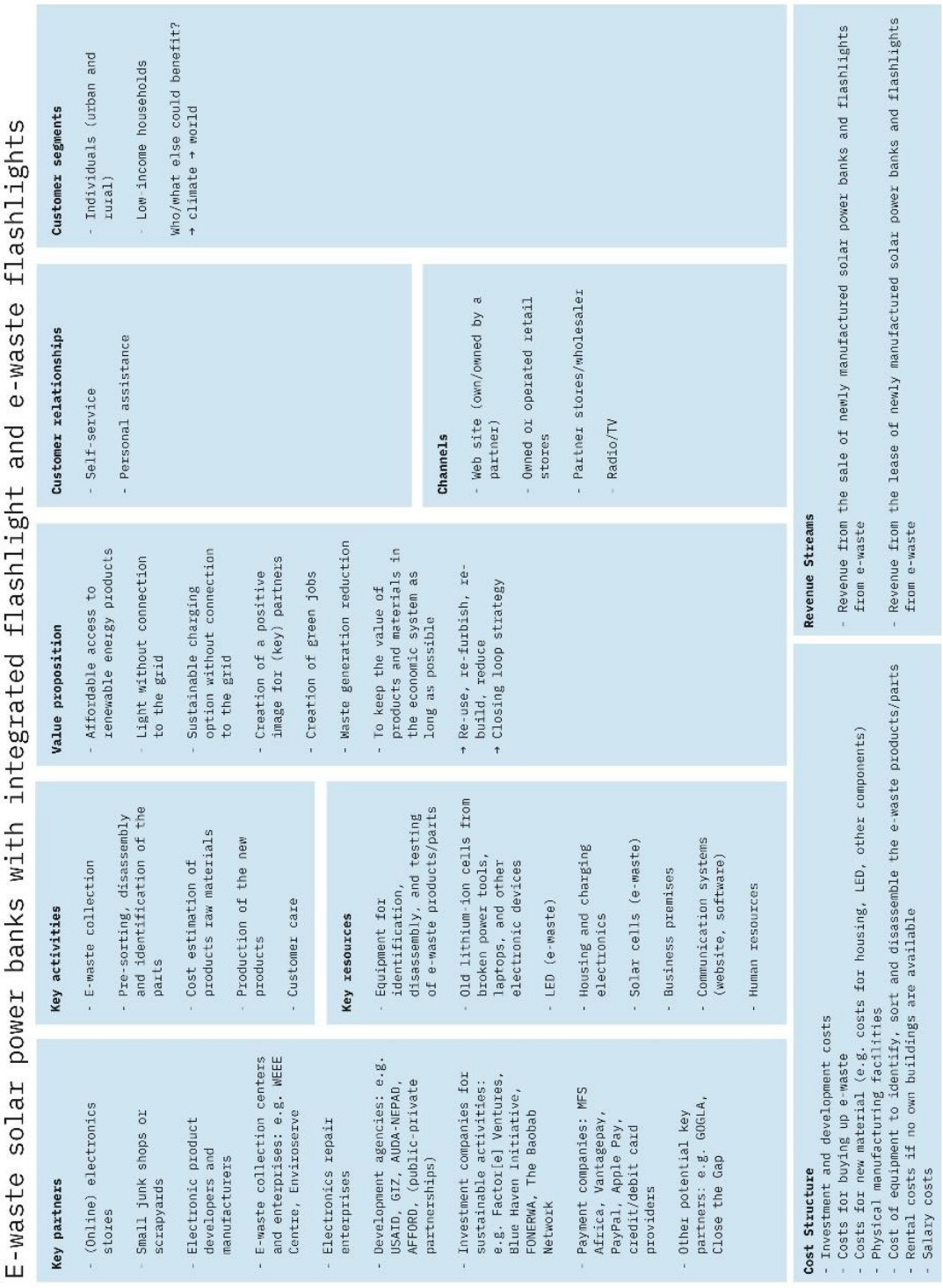


Figure 26 Circular BMC: e-waste solar power banks with integrated flashlight and e-waste flashlights[505]

[505] Own illustration, based on ibid.

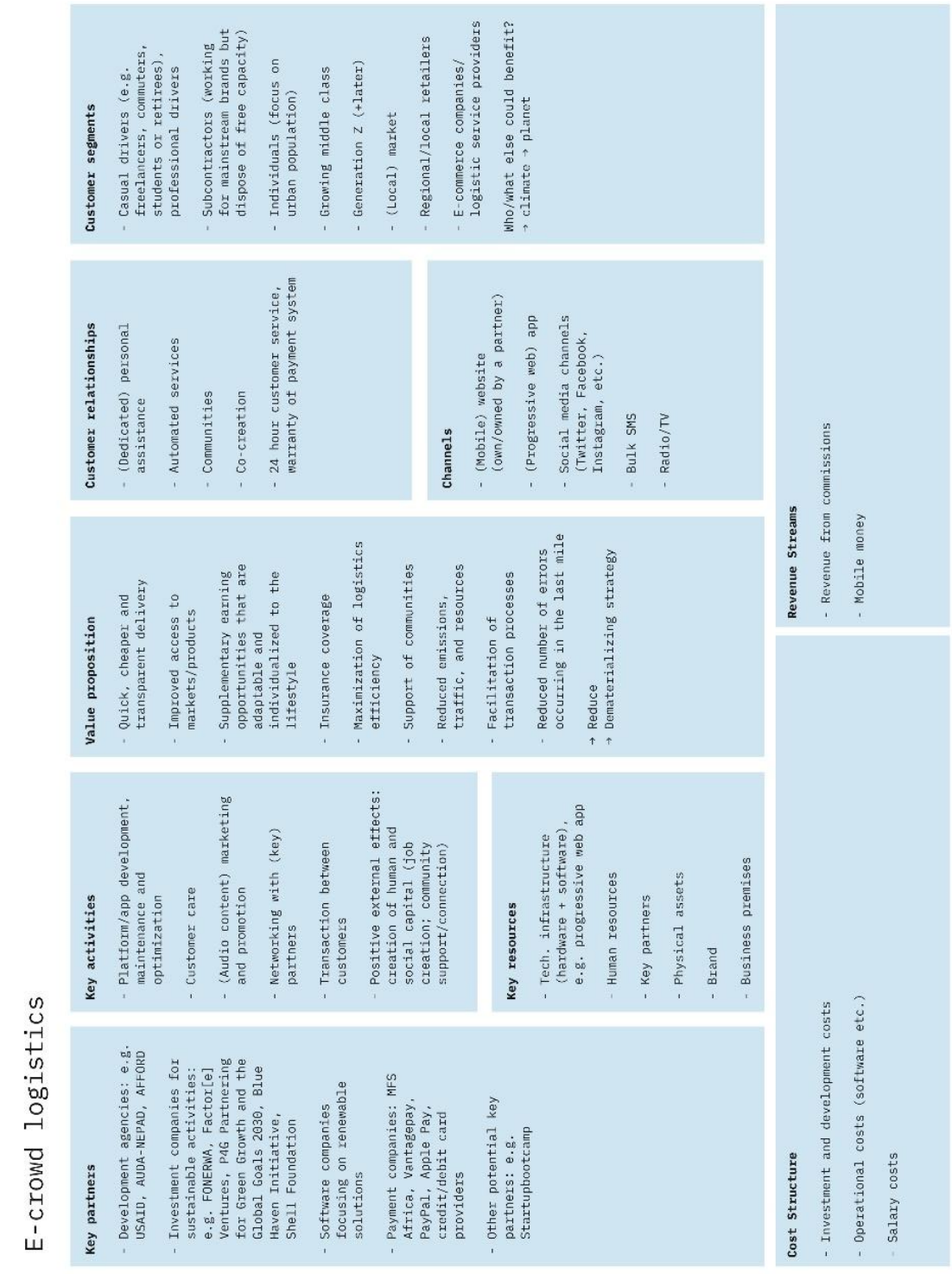


Figure 27 Circular BMC: e-crowd logistics[506]

[506] Own illustration, based on ibid.

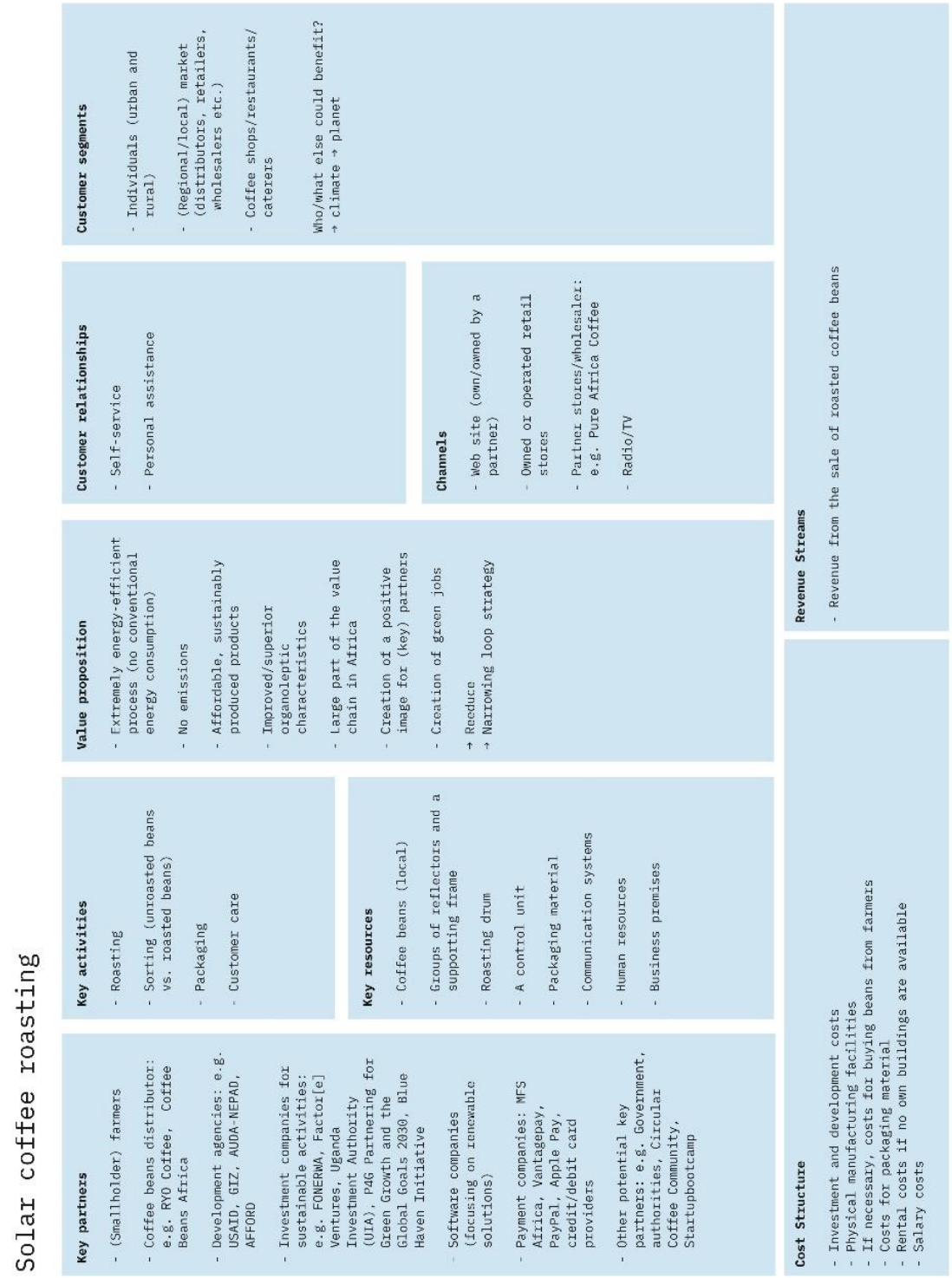


Figure 28 Circular BMC: solar coffee roasting[507]

[507] Own illustration, based on ibid.

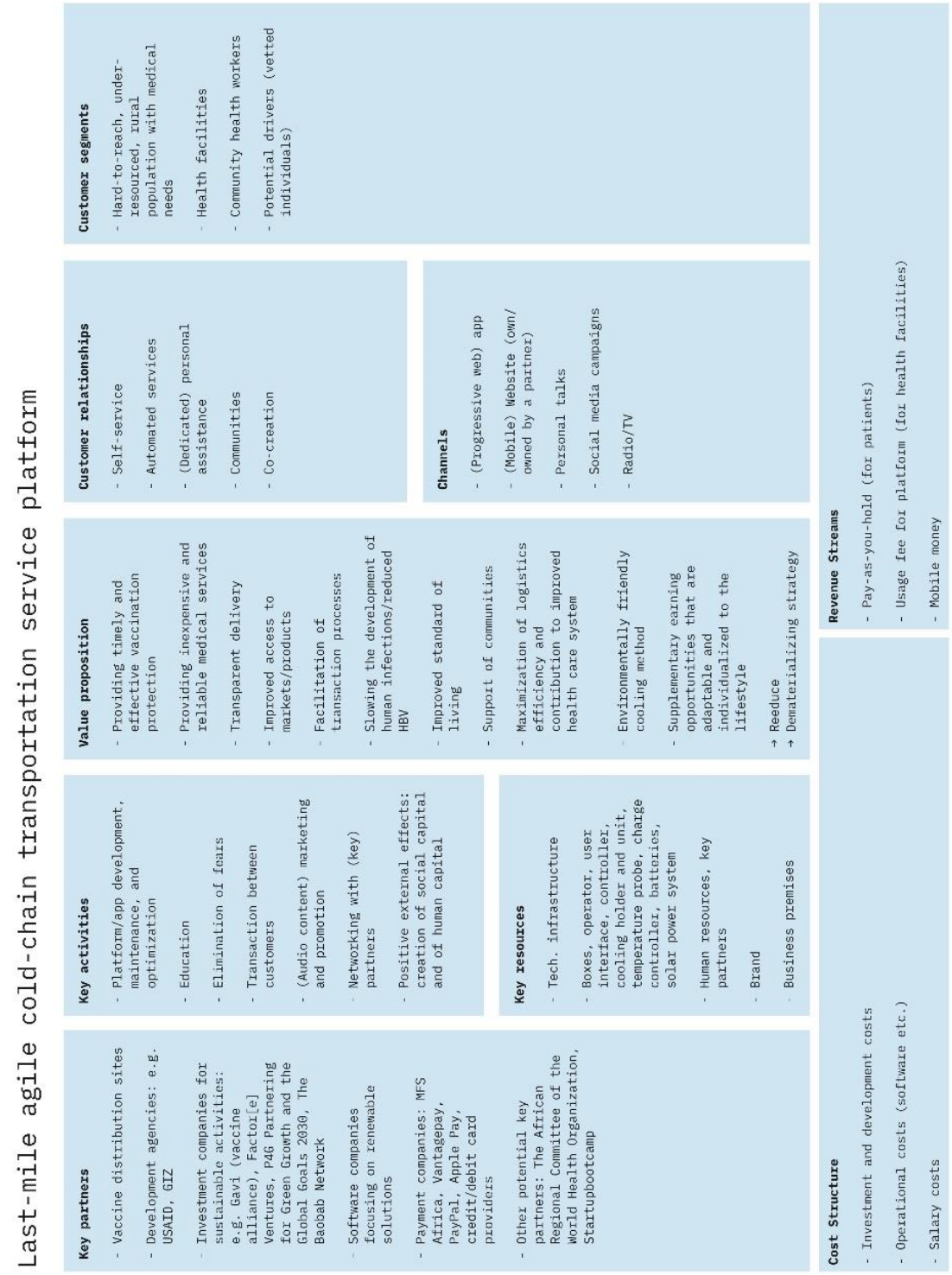


Figure 29 Circular BMC: last-mile agile cold-chain transportation service platform[508]

[508] Own illustration, based on ibid.

4 Results of the evaluated business model ideas

Table 2 (next page) summarizes the expert-rated business model ideas that can be used to tap the potential and address the problems in sub-Saharan countries and are thus best suited for productive use. Ranked first was the business model idea *solar-powered walk-in cooling stations*, followed by *aquaponics* (rank 2), *e-Boda-Boda* (rank 3), *e-waste energy storage* (rank 4), *hemp* (rank 5), *re-commerce* (rank 6), *e-waste solar power banks with integrated flashlight and e-waste flashlights* (rank 7), *e-crowd logistics* (rank 8) and *solar coffee roasting* (rank 9). The business model idea that ranked last was the *last-mile agile cold-chain transportation service platform* (rank 10).

These ten business model ideas can be categorized into three overarching areas: sustainable agriculture, renewable energy, and ICT.

The results demonstrate that the easier the access to required resources, the more attractive the business model idea was perceived (high score value (60-100); highlighted green).

This also applies to the evaluation criteria *amount of capital required*: the lower the capital requirement, the more attractive the idea and the higher the rank (high score value; highlighted green). Additionally, a major benefit (for the economy, end consumers, environment, and society) and a high degree of circularity (high score value; highlighted green) earned a better rank.

Moreover, ideas based on the usage of renewable energy performed better. It is also noted that the business model ideas that are generally more in demand for the African market were better valued. Low complexity of the technology required to implement the business model idea corresponded to a high score value (highlighted green) and thus a better rank. The same applied to the evaluation criteria *external restrictions* and *the need for know-how*. Since this thesis is based on a qualitative literature review, the criterion *profitability* was evaluated only on a qualitative basis. The more profitable an idea was evaluated, the better it ranked.

Criteria that tended to score poorly were highlighted in orange (score values between zero and 40). Score values between 40 and 60 were highlighted in yellow (compare Table 2).

Evaluation criteria \ Business Model Ideas	Aquaponics	E-Boda-Boda	E-crowd logistics	E-waste energy storage	E-waste solar power banks with integrated flashlight and e-waste flashlights	Hemp	Last-mile agile cold-chain transportation service platform	RE-Commerce	Solar coffee roasting	Solar-powered walk-in cooling stations
Access (difficulty & limitation) to required resources	60.5	50.0	78.8	50.0	39.5	74.9	60.5	81.6	60.5	68.3
Amount of capital required (less/a lot)	39.5	35.6	64.4	39.5	50.0	50.0	50.0	71.1	35.6	50.0
Benefit for economy	78.8	78.8	78.8	89.4	89.4	89.4	60.5	85.5	71.1	93.2
Benefit for end consumers	89.4	89.4	93.2	78.8	89.4	64.4	93.2	78.8	78.8	89.4
Benefit for environment	93.2	93.2	89.4	89.4	89.4	78.8	81.6	74.9	89.4	93.2
Benefit for society	93.2	93.2	89.4	89.4	78.8	78.8	78.8	68.3	71.1	89.4
Complexity of technology	46.1	39.5	50.0	28.9	39.5	85.5	28.9	60.5	25.1	71.1
Coverage of circular economy aspects	93.2	71.1	74.9	93.2	93.2	60.5	50.0	85.5	60.5	78.8
External restrictions (e.g. legal)	85.5	64.4	53.9	74.9	74.9	14.5	28.9	39.5	85.5	93.2
Necessity of the business idea for the market	89.4	89.4	60.5	89.4	71.1	60.5	64.4	71.1	60.5	89.4
Need for know-how	46.1	43.3	39.5	39.5	39.5	81.6	28.9	50.0	39.5	78.8
Profitability (qualitative reasoning)	89.4	74.9	53.9	74.9	50.0	89.4	71.1	71.1	71.1	89.4
Use of energy from renewable sources	74.9	93.2	46.1	78.8	74.9	74.9	89.4	50.0	93.2	93.2
Total	**75.3**	**70.5**	**67.1**	**70.5**	**67.7**	**69.5**	**60.5**	**68.3**	**64.8**	**82.9**
Rank	**2**	**3**	**8**	**4**	**7**	**5**	**10**	**6**	**9**	**1**

Table 2 Top 10 ranking of sustainable business model ideas best suited for productive use[509]

[509] Own illustration.

5 Discussion

In the discussion, the research question is first answered based on the previously obtained results and then contrasted and interpreted in the context of the current literature. Thereafter, it is discussed to what extent the ranking is justified given that the research question has now been answered. Furthermore, it is debated for which of the developed business model ideas, the identified prerequisites are equally easy to fulfill, and which ideas are equally promising for productive use in SSA. The end of the discussion points out limitations of the study and potential impact on the findings, coupled with recommendations for further research.

Table 3 shows a summary of the main findings.

Top 10 business model ideas for productive use in SSA:

1) Solar-powered walk-in cooling stations
2) Aquaponics
3) E-Boda-Boda
4) E-waste energy storage
5) Hemp
6) Re-commerce
7) E-waste solar power banks with integrated flashlight and e-waste flashlights
8) E-crowd logistics
9) Solar coffee roasting
10) Last-mile agile cold-chain transportation service platform

➔ Categorization of the ten ideas into three overarching areas: sustainable agriculture, renewable energy, and ICT.

➔ The easier the access to required resources, the better the idea is perceived.
➔ The lower the capital requirement, the higher the rank.
➔ The greater the benefit and the higher the degree of circularity, the higher the rank.
➔ Ideas based on usage of renewable energy perform better.
➔ Ideas more in demand for the African market perform better.
➔ Ideas with a low degree of complexity of the technology perform better.

➔ Ideas related to less external restrictions and less know-how needed perform better.

➔ The more profitable an idea, the better the rank.

Table 3 Summary of key results[510]

Prerequisites needed for successful implementation of sustainable business model ideas

Based on the results (see Table 3; detailed listing see Table 2, previous chapter), the research question, *"What are the prerequisites and how are they defined for the successful implementation of sustainable business model ideas in SSA?",* can be answered. Since experts evaluated ideas more positively if they greatly benefit the economy, end consumers, the environment, and society, the first prerequisite for successful implementation of sustainable business model ideas is ***value delivery***. Accordingly, a major benefit implies excellent value delivery. The key findings of the literature review, listed at the end of each chapter (compare section 2.4.1 - 2.4.4), indicate that the issues of energy, agriculture and natural resources, transportation infrastructure and health should be addressed in particular. Addressing these can generate great benefits, which implies an excellent value delivery, according to the interpretation. It can therefore be inferred, that the more these issues are addressed, the greater the benefit, the more excellent the value delivery, and the more successful the implementation.

The second prerequisite derived from the results is ***promising customers***, defined by the degree of necessity of the business model idea for the African market. The more the product/service is needed, the more promising the customers are. This suggests that business model ideas addressing serious problems such as PHL, health issues like chronic HBV or lack of access to electricity tend to have more promising customers. As can be seen from the literature review, in both Namibia and Senegal, only slightly more than half of the population had access to electricity in 2019 – in Namibia, less than 10 % of the rural population had access. Rwanda also has one of the lowest per capita electricity consumption rates in the Central East African region. In addition, research has shown that for 77 % of Ugandan micro, small and medium enterprises

[510] Own illustration.

surveyed, access to electricity is the most frequently cited barrier to business growth. This 77 %, along with populations in Namibia, Senegal, and Rwanda that do not have access, can be interpreted as very promising customers.

Six of the ten business model ideas address these problems and therefore have very promising customers according to this interpretation. The remaining four ideas (*aquaponics*, *hemp*, *re-commerce* and *e-crowd logistics*) are therefore not less attractive, but address other important problems, such as the transportation problem addressed by *e-crowd logistics*, or the lack of food security addressed by *aquaponics*. Furthermore, addressing such crucial problems through successfully implemented sustainable business models creates numerous positive side effects such as sustainable jobs, improving living standards and medical care, and reducing food insecurity and malnutrition, which can be seen as improving basic needs (food and health care).

The third prerequisite is ***sufficient capital***, defined by the amount of required capital. Since economic growth in SSA has been mostly jobless and characterized by poverty over the past two decades, business model ideas with low capital requirements are more beneficial and promising. The literature review also highlights the imbalance between women and men. Through the analysis of Uganda (compare chapter 2.4.4), it was found that women in the agricultural sector earn almost half as much as men. However, considering that women make up almost half of the agricultural labor force (compare chapter 1), it can be concluded that lower capital requirements are clearly beneficial to the successful implementation of business model ideas in SSA in this sector.

The fourth prerequisite is ***the presence of key resources***, defined by the access (difficulty and limitation) to the required resources. Ease of access represents a more secure presence of critical resources and thus a more promising and suitable business model idea for productive use.

For instance, solar energy, as a crucial resource, can be associated with unlimited access. As evidenced by the literature review, energy access is an important issue, and demand is increasing while the potential for solar energy in SSA is high. Thus, business model ideas based on solar energy are extremely attractive for these countries. The results of chapter 4 show that six of the ten business model ideas are based on solar energy (the boxes used in the *last-mile agile cold-chain transportation service platform* are also cooled using a solar system), highlighting the potential and importance of this resource.

On the contrary, water can be associated with limited access, as it became clear that water scarcity is a serious challenge for the countries studied. Rising temperatures triggered by climate change are exacerbating this challenge. Although *aquaponics* (compare chapter 2.5.1) is an integrated closed loop system and therefore water waste is extremely low, access to water for implementation must be guaranteed as it is the most important medium in this system. Even though the business model idea was ranked second, it is questionable whether this idea can still be implemented successfully in the future, given the fourth identified and defined prerequisite.

Additionally, ***the possibility of performing the key activities*** can be derived from the results as a further (fifth) prerequisite. This dimension can be defined on the one hand by the degree of the complexity of the technology and, on the other hand, by the required know-how, and the external restrictions that can influence the implementation of a sustainable business model idea in SSA.

A low degree of technological complexity, fewer external restrictions (e.g., legal), and less required know-how (highlighted in green in Table 2 in the previous chapter) represent an easy way to carry out crucial activities. Applying this definition to the results, one can see that *last-mile agile cold-chain transportation service platform* performs the worst and is therefore less attractive (all three criteria highlighted in orange; score values ≤ 40). At the beginning of this discussion, it was noted that, among other things, the more the aspect of health is addressed in a business model idea, the greater the benefit, the more excellent the value delivery, and the more successful the implementation. At this point, however, it becomes evident that apparently successful implementation can be negatively influenced by other prerequisites. From this finding, it can thus be deduced that it is not sufficient to consider only one prerequisite for a successful implementation, but that all defined prerequisites should be predominantly fulfilled.

Since this thesis focuses on implementing sustainable business model ideas, ***sustainability*** is the sixth prerequisite defined by the degree of circularity and the usage of energy from renewable sources. The more the concept of circular economy is pursued and the more energy from renewable sources is used, the more sustainable the ideas become.

The literature review highlights the importance and increasing presence of sustainability in today's world, whether through the pursuit of improved resource efficiency or even efforts to counteract climate change. It shows that sustainability is

not only defined by the three pillars (social, economic, and environmental pillar) but has been expanded to include the component of technology and is considered a driver of innovation. As it turns out, the sustainable top ten business model ideas are, inter alia, based on ICT.

Re-commerce can be interpreted as an innovation of e-commerce, driven by the sustainability aspect by pursuing a dematerializing strategy and focusing on re-using, reducing, and re-furbishing resources.

In addition, *e-crowd logistics* can be understood as an innovation of conventional logistics, which is also driven by the aspect of sustainability by using free space and thus saving additional trips, which in turn has a positive impact on the environment. Interestingly, research shows (compare chapter 2.7.2) that people's transportation choices are crucial to the sustainability of crowd logistics. Therefore, it is extremely important to educate people about their transportation choice and encourage sustainable conduct, as well as provide incentives to behave consciously. In Rwanda, for example, environmentally friendly transport is already being promoted, as has been shown by the analysis.

Lastly, ***profitability***, defined by qualitative reasoning, can be identified as the seventh prerequisite. Looking at the results, it can be criticized that the qualitative reasoning of the individual experts based on the given data can contain unconscious cognitive biases and thus unintentionally influences the evaluation and ultimately the ranking of the business model ideas. For example, the so-called "halo effect", in which a single aspect of a person is so dominant that other aspects are not, or even superficially considered in the evaluation of this person, represents a real threat in this case in a modified form (instead of persons, business model ideas were evaluated here).

Next to unconscious biases, the Canvas building blocks *key partners*, *customer segments* and *relationships*, *channels*, *cost structure*, and *revenue streams* can influence the identified prerequisites. For instance, key partners committed to the environment can positively affect fulfilling *sustainability*. Customer segments and relationships as well as channels are among the factors that determine how promising customers are. These should be precisely aligned with the addressed problem of the business model idea to find *promising customers*. Furthermore, the building blocks *revenue streams* and *cost structure* can indirectly influence *sufficient capital*, as the cost structure shows, for example, which costs are incurred and thus determines the amount of capital required.

The extent to which the ranking can be justified

Now that all the prerequisites for a successful implementation of sustainable business model ideas have been identified and defined, the ranking from the expert assessment (see Table 2) has become more comprehensible. Additionally, the ranking can be justified even better, but also more justified criticism can be made.

For instance, rank 1 (*solar-powered walk-in cooling stations*) addresses serious problems (PHL, lack of access to electricity as well as human infections), which, according to the interpretation, implies an excellent value delivery and pledges very promising customers. Since the idea is based on solar energy, the fourth requirement (*presence of key resources*) can be met very easily. Overall, this idea is the only one for which all evaluation criteria except for the criterion "capital requirement", which is rated as moderate (score value = 50; highlighted in yellow), are rated very positively/as very attractive (score values ≥ 60; highlighted in green), indicating the best prerequisites, and thus the first rank is justified.

Re-commerce and *e-crowd logistics* were rated as the only ideas with rather low capital requirements. However, this rating can be criticized if one assumes that, for instance, Senegalese farmers, who make their living primarily from small-scale agriculture (compare chapter 2.4.3), want to operate *solar coffee roasting* on a small scale and require little capital. In addition, this idea addresses the problem of access to electricity and solves it sustainably because it is based on solar energy. Furthermore, as the literature review indicates (compare chapter 2.6.1), about 70 % of the world's harvested coffee is exported to developed countries for further processing due to the lack of processing and logistics facilities in producing countries. S*olar coffee roasting* would allow coffee to be processed locally, bringing part of the value chain back to Africa, resulting in an increase of farmers´ income. Though, *solar coffee roasting* is ranked 9th and classified as tending to be very capital intensive.

Also, the place of *hemp* (rank 5) can be discussed since this business model idea can very quickly replace better-ranked ideas simply through individual political decisions on legalization. Apart from the external legal restrictions, the idea is considered promising (compare Table 2 in the previous chapter). Reviewing the literature (compare chapter 2.5.2), it becomes clear that the legalization of hemp cultivation is increasing, so it is only a matter of time before hemp displaces better-ranked ideas.

Fulfillment of identified prerequisites for business model ideas and promise for productive use in SSA

After all prerequisites have been identified and defined, it also becomes apparent that not all of them are equally easy to fulfill, and not all business model ideas are equally promising for productive use in SSA.

For example, *solar coffee roasting* is better suited for coffee-producing countries such as Rwanda and Uganda. These businesses would require non-coffee producing countries to source coffee beans from abroad, negatively impacting *sustainability* and *the presence of key resources* due to logistical challenges.

Furthermore, *e-crowd logistics*, for example, is particularly promising for Rwanda and Senegal at first glance: In Senegal, many businesspeople commute daily but travel time to work is often unnecessarily long and the delivery of goods is often hindered by heavy traffic congestion. And the transport sector is the main contributor to urban air pollution in Rwanda and is insufficient to meet peak demand (compare chapters 2.4.2 and 2.4.3). However, the literature review also highlights the importance of population density in crowd logistics (compare chapter 2.7.2), stating that increasing population density in cities has laid the foundation for a critical mass that forms the backbone of crowd logistics platforms. Regarding this finding, *e-crowd logistics* is less promising for Senegal´s low population density. Rwanda is home to one of the highest population densities in the world, making it very suitable for *e-crowd logistics*. Additionally, it has been found that Uganda will experience a demographic boom, leading to a significant increase in its population density (compare chapter 2.4.4).

Also, *re-commerce* is especially promising for Rwanda, which is, according to the analysis, a well-known tech hub on the African continent, and it turned out that e-commerce is relatively new and not widespread so far (compare chapter 2.4.2). This constitutes a competitive advantage, as companies in this industry do not have to compete against already established companies. Advantageously, the market volume of e-commerce in Rwanda is forecast to almost double to 728 million USD by 2025 (compare chapter 2.4.2).

E-Boda-Boda is notably attractive for Uganda, as the most common form of motorized transport is Boda-Bodas, and to make the transport sector more profitable, there is a need to introduce less vulnerable infrastructure that can both provide cost-effective services and reduce greenhouse gas emissions (compare chapter 2.4.4).

In addition to *e-Boda-Boda*, *solar-powered walk-in cooling stations* are very promising for Uganda because, as revealed by the analysis (compare chapter 2.4.4), refrigerators are the most frequently mentioned potential electrical appliances to increase the profitability of existing small and medium enterprises and income-generating activities, as well as of potential new businesses.

As shown in the analysis, Senegal´s inhabitants represent a highly educated and skilled workforce (compare chapter 2.4.3). For this reason, business model ideas that require a great deal of expertise for successful implementation and are based on very complex technology (e.g., business model ideas on rank 3,4, 7, 8, 9, and 10), are more suitable for the Senegalese market.

Nevertheless, the analysis also identified business model ideas for which the prerequisites are equally easy/difficult to fulfill and equally promising in all countries. Such a business model idea is, for instance, *aquaponics*. As shown in the literature review of the countries, more than half of the population in SSA is employed in the agricultural sector. Therefore, promoting sustainable ideas for the primary industry and increasing its productivity is essential and greatly benefits society, end consumers, the economy and the environment, which in turn implies an excellent *value delivery* (first defined prerequisite).

Due to the overall population increase in SSA, demand and thus the customer base for agricultural products is steadily growing, which can be interpreted as an increase in promising customers and thus a better second prerequisite (*promising customers*).

The urbanization that accompanies population growth indicates that agriculture will no longer be limited to rural areas in the future. A growing population also implies increasing strain on critical resources. Additionally, climate change is putting more and more strain on the work of farmers and fisheries. As reflected in the literature review (compare section 2.4), by 2060, many people in SSA will be at risk of food insecurity and malnutrition because, inter alia, 60 to 90 million hectares of land will be affected by intense drought. Furthermore, the COVID-19 pandemic has exacerbated nutrition-related problems on the continent.

Here, *aquaponics* can offer excellent benefit as a sustainable concept for the agricultural sector. Fish in particular play an important role in battling malnutrition. Additionally, fish in RAS uses the least water of all food production systems (compare chapter 2.5.1). Moreover, the concept reduces logistics costs, as fish can be cultivated directly in urban areas rather than being confined to rural areas. Thus, these factors

positively impact the prerequisite of *sufficient capital*, *profitability,* and *sustainability*. Since *aquaponics* can be operated independently of location, the prerequisite *possibility to perform key activities* is equally easy to fulfill in SSA. The fourth prerequisite (*the presence of key resources*) is equally difficult to fulfill everywhere because, as mentioned above, water is the most important medium in the aquaponics system, and there is water scarcity in all four countries studied (compare section 2.4.1-2.4.4).

Limitations and need for further research

Because of the methodology chosen, a comprehensive literature review, two major limitations can be identified. First, the categorization of the information is definitively affected by researcher bias, which greatly affects the identification of the ten business model ideas.

The second major limitation relates to the lack of on-site interviews. Thus, an individual assessment by those who daily face challenges in SSA is lacking. Therefore, future research could empirically assess the applicability of the proposed business model ideas and the prerequisites derived from them by focusing on local surveys.

In addition, future research can use the insights gained in this thesis as a starting point and develop sustainable business model ideas for the sectors that have not been considered so far, which also have great potential. At the end of each country analysis (see chapter 2.4.1-2.4.4), the most important results were listed. These showed the sectors with particularly high potential. Among others, the tourism sector and the real estate and construction sector were identified as sectors with high potential. Since business models in the construction and real estate sector tend to be capital-intensive, this identified sector was not considered further in this thesis. The tourism sector was also excluded.

Coming back to the quote of Elumelu presented at the beginning, that Africans need jobs and role models, and that they need to see that they don´t need to migrate out of the continent to earn a living or to earn a decent life, the following can now be concluded at the end of this thesis:

First, Elumelu can be proved right that Africans need jobs. Second, this thesis adds the aspect of sustainability to this statement by asserting that Africans need sustainable jobs to address unemployment in the long run which has constituted economic growth

in SSA. Sustainable business model ideas, which are developed and presented in this thesis (see chapter 3), create such jobs. These business model ideas tap the existing potential of the countries in SSA for the benefit of society, end customers, the economy, and the environment, thus enabling an economic and social upswing, while at the same time demonstrating that prevailing problems can be solved sustainably. In this way, the growing working-age population is more aware of what their homeland has to offer and that there is no reason to leave the continent. The untapped potential and opportunities only need to be exploited. This thesis aims to show that SSA offers good conditions to earn a secure living and live a decent life by developing a ranking of ten business model ideas best suited for productive use. By answering the research question, it is shown which prerequisites must be met for the successful implementation of these ideas.

Finally, it bears noting that women in Africa, as described at the outset, play a decisive role in boosting the economy, reducing poverty, and improving living standards. Therefore, it is essential to bring male-dominated sectors closer to women, educate and encourage them, and steadily consider the role of women in the realization of the sustainable business model ideas described in this thesis.

6 Conclusion

The overall purpose of this thesis was to identify and define prerequisites for the successful implementation of sustainable business model ideas in SSA. For this purpose, ten ranked ideas were developed that are best suited for productive use in SSA, thereby increasing economic growth and reducing poverty and inequality. With the help of extensive literature research, the ideas were elaborated and evaluated by experts. The ranking of the ideas was performed using fuzzy logic with artificial intelligence, based on the system for exploring country risks (CRISK-Explorer) for larger and smaller emerging market countries proposed by Steurer in "Quantitative Country Risk Assessment".

Agriculture, renewable energy, and ICT are found to be the most promising sectors for the ten sustainable business model ideas. Ranked first was the business model idea *solar-powered walk-in cooling stations*, followed by *aquaponics* (rank 2), *e-Boda-Boda* (rank 3), *e-waste energy storage* (rank 4), *hemp* (rank 5), *re-commerce* (rank 6), *e-waste solar power banks and flashlights* (rank 7), *e-crowd logistics* (rank 8) and *solar coffee roasting* (rank 9). The last ranked business model idea was the *last-mile agile cold-chain transportation service platform* (rank 10).

Seven prerequisites for the successful implementation of these ideas were identified and defined: *value delivery*, *promising customers*, *sufficient capital*, *the presence of key resources*, *the possibility to perform the key activities*, *sustainability*, and *profitability*.

It has also become apparent that the prerequisites for all business model ideas are not equally easy to fulfill in all countries and the ideas are not equally promising for productive use in SSA. However, this should not be seen as an obstacle given that the potential of SSA, with its natural resources and the large working-age population that continues to grow, is great and should be tapped. After all, if this demographic group finds meaningful employment, Africa could experience an upswing; if not, they will most likely migrate out of the continent.

At the end of this thesis, it can now be stated that the goals set at the beginning have been achieved by the results and through the developed ranking of sustainable business model ideas for productive use in SSA, a gap in the current literature has thereby been closed. Through participation in webinars as an addition to the comprehensive literature review, this thesis realized a novel approach with up-to-date data for

entrepreneurs who want to implement future-oriented sustainable business models best suited for productive use in SSA. In addition, it contributed to theoretical research by developing a circular BMC framework.

Because an extensive literature review was chosen as the methodology for this work, two major limitations were identified. First, the categorization of the information is definitively affected by researcher bias. The second limitation relates to the lack of on-site interviews. Thus, an individual assessment by those who face challenges in SSA daily is lacking. Therefore, as a continuation of the present thesis, future research could empirically assess the applicability of the proposed business model ideas and the prerequisites derived from them by focusing on local surveys.

Based on this work, a scientific paper entitled "Top 10 Business Models for Productive Use in Sub-Saharan Africa" was written and presented at the conference "Universities, Entrepreneurship, and Enterprise Development in Africa" in Sankt Augustin (Germany). This paper will be published at the end of October 2022.

Appendix

Appendix 1: Technical specifications of the single reflector (coffee roasting with the help of sunlight)

Technical Specifications of the single Reflector:

- 2-axis motorized aiming system
- Autonomous power supply with photovoltaic cell
- Optical aiming accuracy: better than 0.1 degrees
- Dual processor electronic control
- Wireless connection with the Control Unit
- 19 Photoelectric sensors
- Watertight photo-detector container
- Reflective surfaces: 3 mm safety glass
- Reflectivity: 90%
- Aluminum-Magnesium alloy support frame
- Reflective surface area: mq. 0.5
- Maximum equivalent radiant power: 450 W.
- Dimensions: 500 x 500 x 800 mm
- Weight kg. 8

Figure 30 Technical specifications of the single reflector[511]

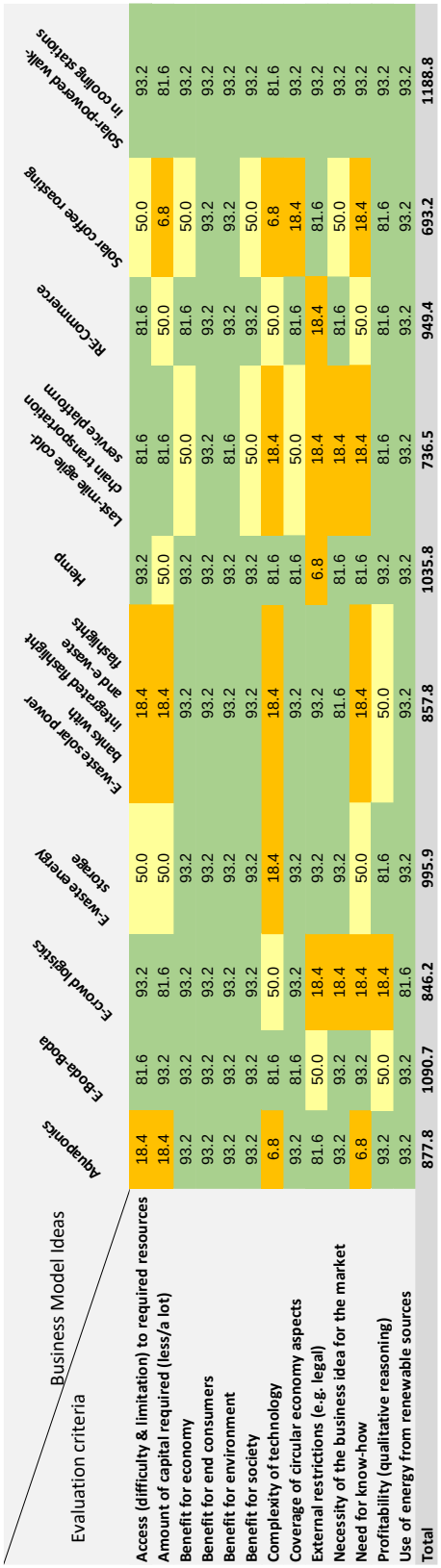
[511] PuroSole, 'Solar Coffee Roasting'.

Appendix 2: Detailed assessments of the business model ideas by the individual experts

Evaluation - Top 10 Business Model Ideas Suited Best for Productive Use in SSA											
Evaluation criteria \ Business Model Ideas	Aquaponics	E-Boda-Boda	E-crowd logistics	E-waste energy storage	E-waste solar power banks with integrated flashlight and e-waste flashlights	Hemp	Last-mile agile cold-chain transportation service platform	Re-Commerce	Solar coffee roasting	Solar-powered walk-in cooling stations	
Access (difficulty & limitation) to required resources	2	4	5	3	2	5	4	4	3	5	
Amount of capital required (less/a lot)	2	5	4	3	2	3	4	3	1	4	
Benefit for economy	5	5	5	5	5	5	3	4	3	5	
Benefit for end consumers	5	5	5	5	5	5	5	5	5	5	
Benefit for environment	5	5	5	5	5	5	4	5	5	5	
Benefit for society	5	5	5	5	5	5	3	5	3	5	
Complexity of technology	1	4	3	2	2	4	2	3	1	4	
Coverage of circular economy aspects	5	4	5	5	5	4	3	4	2	5	
External restrictions (e.g. legal)	4	3	2	5	5	1	2	2	4	5	
Necessity of the business idea for the market	5	5	2	5	4	4	2	4	3	5	
Need for know-how	1	5	2	3	2	4	2	3	2	5	
Profitability (qualitative reasoning)	5	3	2	4	3	5	4	4	4	5	
Use of energy from renewable sources	5	5	4	5	5	5	5	5	5	5	
											1 - very negative
											2 - negative
											3 - moderate
											4 - positive
											5 - very positive

Table 4 Assessment table expert 1[512]

[512] Own illustration.



Evaluation criteria \ Business Model Ideas	Aquaponics	E-Boda-Boda	E-crowd logistics	E-waste energy storage	E-waste solar power banks with integrated flashlight and e-waste flashlights	Hemp	Last-mile agile cold-chain transportation service platform	RE-Commerce	Solar coffee roasting	Solar-powered walk-in cooling stations
Access (difficulty & limitation) to required resources	18.4	81.6	93.2	50.0	18.4	93.2	81.6	81.6	50.0	93.2
Amount of capital required (less/a lot)	18.4	93.2	81.6	50.0	18.4	50.0	81.6	50.0	6.8	81.6
Benefit for economy	93.2	93.2	93.2	93.2	93.2	93.2	50.0	81.6	50.0	93.2
Benefit for end consumers	93.2	93.2	93.2	93.2	93.2	93.2	93.2	93.2	93.2	93.2
Benefit for environment	93.2	93.2	93.2	93.2	93.2	93.2	81.6	93.2	93.2	93.2
Benefit for society	93.2	93.2	93.2	93.2	93.2	93.2	50.0	93.2	50.0	93.2
Complexity of technology	6.8	81.6	50.0	18.4	18.4	81.6	18.4	50.0	6.8	81.6
Coverage of circular economy aspects	93.2	81.6	93.2	93.2	93.2	81.6	50.0	81.6	18.4	93.2
External restrictions (e.g. legal)	81.6	50.0	18.4	93.2	93.2	6.8	18.4	18.4	81.6	93.2
Necessity of the business idea for the market	93.2	93.2	18.4	93.2	81.6	81.6	18.4	81.6	50.0	93.2
Need for know-how	6.8	93.2	18.4	50.0	18.4	81.6	18.4	50.0	18.4	93.2
Profitability (qualitative reasoning)	93.2	50.0	18.4	81.6	50.0	93.2	81.6	81.6	81.6	93.2
Use of energy from renewable sources	93.2	93.2	81.6	93.2	93.2	93.2	93.2	93.2	93.2	93.2
Total	877.8	1090.7	846.2	995.9	857.8	1035.8	736.5	949.4	693.2	1188.8

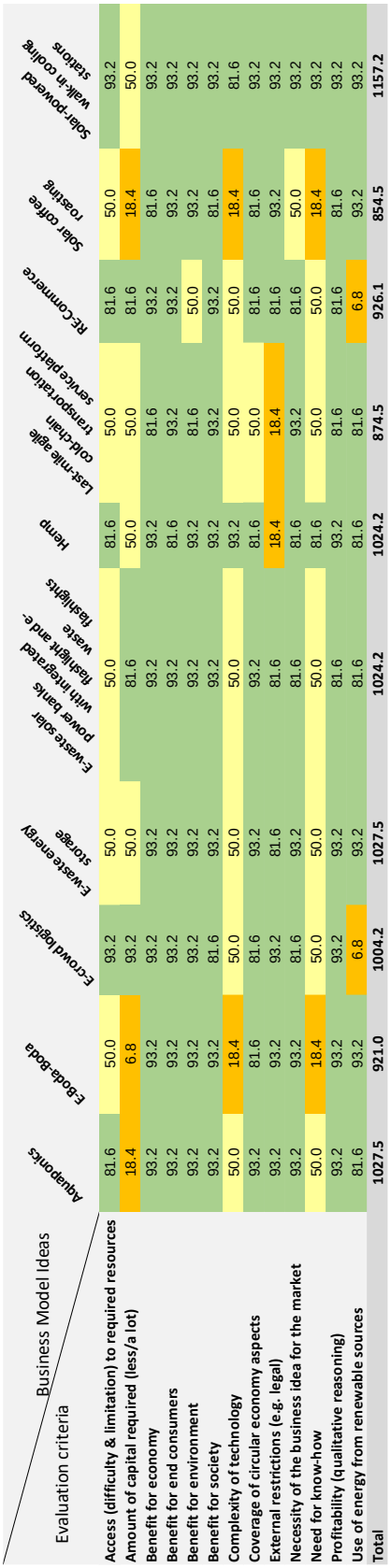
Table 5 Ranking expert 1[513]

[513] Ibid.

Evaluation - Top 10 Business Model Ideas Suited Best for Productive Use in SSA												
Evaluation criteria / Business Model Ideas	Aquaponics	E-Boda-Boda	E-crowd logistics	E-waste energy storage	E-waste solar power banks with integrated flashlight and flashlights	Hemp	Last-mile agile cold-chain transportation service platform	RE-Commerce	Solar coffee roasting	Solar-powered walk-in cooling stations		
Access (difficulty & limitation) to required resources	4	3	5	3	3	4	3	4	3	5		
Amount of capital required (less/a lot)	2	1	5	3	4	3	3	4	2	3		
Benefit for economy	5	5	5	5	5	5	4	5	4	5		
Benefit for end consumers	5	5	5	5	5	4	5	5	5	5		
Benefit for environment	5	5	5	5	5	5	4	3	5	5		
Benefit for society	5	5	4	5	5	5	5	5	4	5		
Complexity of technology	3	2	3	3	3	5	3	3	2	4		
Coverage of circular economy aspects	5	4	4	5	5	4	3	4	4	5		
External restrictions (e.g. legal)	5	5	5	4	4	2	2	4	5	5		
Necessity of the business idea for the market	5	5	4	5	4	4	5	4	3	5		
Need for know-how	3	2	3	3	3	4	3	3	2	5		
Profitability (qualitative reasoning)	5	5	5	5	4	5	4	4	4	5		
Use of energy from renewable sources	4	5	1	5	4	4	4	1	5	5		
											1 - very negative	
											2 - negative	
											3 - moderate	
											4 - positive	
											5 - very positive	

Table 6 Assessment table expert 2[514]

[514] Ibid.



Evaluation criteria \ Business Model Ideas	Aquaponics	E-Boda-Boda	E-crowd logistics	E-waste energy storage	E-waste-solar power banks with integrated flashlight and e-waste flashlights	Hemp	Last-mile eBike cold-chain transportation service platform	RE-Commerce	Solar coffee roasting	Solar-powered walk-in cooling stations
Access (difficulty & limitation) to required resources	81.6	50.0	93.2	50.0	50.0	81.6	50.0	81.6	50.0	93.2
Amount of capital required (less/a lot)	18.4	6.8	93.2	50.0	81.6	50.0	50.0	81.6	18.4	50.0
Benefit for economy	93.2	93.2	93.2	93.2	93.2	93.2	81.6	93.2	81.6	93.2
Benefit for end consumers	93.2	93.2	93.2	93.2	93.2	81.6	93.2	93.2	93.2	93.2
Benefit for environment	93.2	93.2	93.2	93.2	93.2	93.2	81.6	50.0	93.2	93.2
Benefit for society	93.2	93.2	81.6	93.2	93.2	93.2	93.2	93.2	81.6	93.2
Complexity of technology	50.0	18.4	50.0	50.0	50.0	93.2	50.0	50.0	18.4	81.6
Coverage of circular economy aspects	93.2	81.6	81.6	93.2	93.2	81.6	50.0	81.6	81.6	93.2
External restrictions (e.g. legal)	93.2	93.2	93.2	81.6	81.6	18.4	18.4	81.6	93.2	93.2
Necessity of the business idea for the market	93.2	93.2	81.6	93.2	81.6	81.6	93.2	81.6	50.0	93.2
Need for know-how	50.0	18.4	50.0	50.0	50.0	81.6	50.0	50.0	18.4	93.2
Profitability (qualitative reasoning)	93.2	93.2	93.2	93.2	81.6	93.2	81.6	81.6	81.6	93.2
Use of energy from renewable sources	81.6	93.2	6.8	93.2	81.6	81.6	81.6	6.8	93.2	93.2
Total	1027.5	921.0	1004.2	1027.5	1024.2	1024.2	874.5	926.1	854.5	1157.2

Table 7 Ranking expert 2[515]

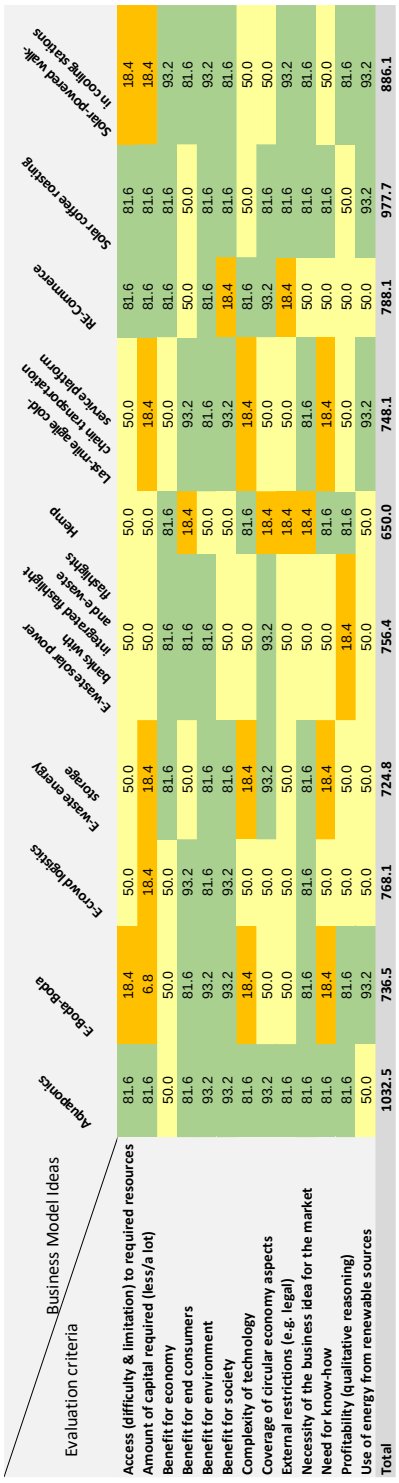
[515] Own illustration.

Evaluation - Top 10 Business Model Ideas Suited Best for Productive Use in SSA										
Business Model Ideas / Evaluation criteria	Aquaponics	E-Boda-Boda	E-crowd logistics	E-waste energy storage	E-waste solar power banks with integrated flashlight and e-waste flashlights	Hemp	Last-mile agile cold-chain transportation service platform	RE-Commerce	Solar coffee roasting	Solar-powered walk-in cooling stations
Access (difficulty & limitation) to required resources	4	2	3	3	3	3	3	4	4	2
Amount of capital required (less/a lot)	4	1	2	2	3	3	2	4	4	2
Benefit for economy	3	3	3	4	4	4	3	4	4	5
Benefit for end consumers	4	4	5	3	4	2	5	3	3	4
Benefit for environment	5	5	4	4	4	3	4	4	4	5
Benefit for society	5	5	5	4	3	3	5	2	4	4
Complexity of technology	4	2	3	2	3	4	2	4	3	3
Coverage of circular economy aspects	5	3	3	5	5	2	3	5	4	3
External restrictions (e.g. legal)	4	3	3	3	3	2	3	2	4	5
Necessity of the business idea for the market	4	4	4	4	3	2	4	3	4	4
Need for know-how	4	2	3	2	3	4	2	3	4	3
Profitability (qualitative reasoning)	4	4	3	3	2	4	3	3	3	4
Use of energy from renewable sources	3	5	3	3	3	3	5	3	5	5

1 - very negative
2 - negative
3 - moderate
4 - positive
5 - very positive

Table 8 Assessment table expert 3[516]

[516] Ibid.



Evaluation criteria \ Business Model Ideas	Aquaponics	E-book-Boda	E-crowd logistics	E-waste energy storage	E-waste-solar power banks with integrated flashlight and e-waste flashlights	Hemp	Last-mile agile cold chain transportation service platform	RE-commerce	Solar coffee roasting	Solar-powered walk-in cooling stations
Access (difficulty & limitation) to required resources	81.6	18.4	50.0	50.0	50.0	50.0	50.0	81.6	81.6	18.4
Amount of capital required (less/a lot)	81.6	6.8	18.4	18.4	50.0	50.0	18.4	81.6	81.6	18.4
Benefit for economy	50.0	50.0	50.0	81.6	81.6	81.6	50.0	81.6	81.6	93.2
Benefit for end consumers	81.6	81.6	93.2	50.0	81.6	18.4	93.2	50.0	50.0	81.6
Benefit for environment	93.2	93.2	81.6	81.6	81.6	50.0	81.6	81.6	81.6	93.2
Benefit for society	93.2	93.2	93.2	81.6	50.0	50.0	93.2	18.4	81.6	81.6
Complexity of technology	81.6	18.4	50.0	18.4	50.0	81.6	18.4	81.6	50.0	50.0
Coverage of circular economy aspects	93.2	50.0	50.0	93.2	93.2	18.4	50.0	93.2	81.6	50.0
External restrictions (e.g. legal)	81.6	50.0	50.0	50.0	50.0	18.4	50.0	18.4	81.6	93.2
Necessity of the business idea for the market	81.6	81.6	81.6	81.6	50.0	18.4	81.6	50.0	81.6	81.6
Need for know-how	81.6	18.4	50.0	18.4	50.0	81.6	18.4	50.0	81.6	50.0
Profitability (qualitative reasoning)	81.6	81.6	50.0	50.0	18.4	81.6	50.0	50.0	50.0	81.6
Use of energy from renewable sources	50.0	93.2	50.0	50.0	50.0	50.0	93.2	50.0	93.2	93.2
Total	**1032.5**	**736.5**	**768.1**	**724.8**	**756.4**	**650.0**	**748.1**	**788.1**	**977.7**	**886.1**

Table 9 Ranking expert 3[517]

[517] Ibid.

Appendix 3: Digital Appendix (Ranking list MS Excel)

For the online submission, the digital appendix is created in an extra file (Appendix 3_Ranking list).

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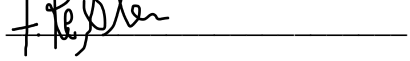

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