Top 10 Business Model Ideas for Productive Use in Sub-Saharan Africa

Elmar Steurer, Inken Hoeck & Franziska Keßler
Neu-Ulm University of Applied Sciences
Germany
email: Franziska.Maria.Kessler@gmail.com
email: Elmar.Steurer@hnu.de
email: Inken.Hoeck@hs-neu-ulm.de

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 experiences an economic and social upswing. To tap this potential, the paper 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 achieves 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 paper focuses on Namibia, Rwanda, Senegal, and Uganda. An extensive literature review on these countries was conducted to gain a broader understanding of the situation in SSA. Additionally, research was carried out on the agricultural, energy, and information and communications technology (ICT) sectors to identify the most promising ideas. To contribute to current knowledge, experts were interviewed, and panel discussions were analyzed. Furthermore, the Business Model Canvas (BMC) was combined with the circular economy concept, which served 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 paper 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, presence of key resources, possibility to perform the key activities, sustainability, and profitability. The paper concludes by identifying limitations and suggesting avenues for future research.

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Introduction

Over the past two decades, sub-Saharan Africa (SSA) has witnessed relatively strong economic growth (Shimeles et al., 2018). In the process, Africa is leapfrogging – the absence of retail chains could, for instance, lead to a surge in e-commerce (Bogner & Hertzberg, 2021). 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 to 150 million worldwide (Shimeles et al., 2018).

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 by about 45 %, with a continuing upward trend (Shimeles et al., 2018). 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 (The World Bank Group, 2021d). Moreover, the young and working-age populations are forecast to expand (The World Bank Group, 2022). While currently, 14 % of the world's working-age population lives in SSA, this figure will predictably be higher than the rest of the world combined by 2036 (Bogner & Hertzberg, 2021). Hence, African challenges must be addressed, and the untapped potential and opportunities in SSA exploited to increase economic growth for the benefit of the population. One way to do this is by developing and implementing sustainable business model ideas. Therefore, the paper addresses the question of the prerequisites and how they are 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 paper focuses on the countries Namibia, Rwanda, Senegal, and Uganda.

The paper is organized as follows. Section 2 presents the concept of this paper and the methodological choices. Section 3 shows a conceptualization of an extended framework for sustainable business models – the Business Model Canvas (BMC) with an integrated aspect of the circular economy. This section is followed by a review of recent literature on current challenges in SSA and promising business ideas best suited for productive use (section

4 and 5). Section 6 presents the results in the context of a top ten ranking, followed by a discussion of the results (section 7). Section 8 provides the conclusion, including limitations and suggestions for further research.

Methodology

An extensive literature review was conducted on the countries Namibia, Rwanda, Senegal, and Uganda, as well as on the agricultural, energy, and ICT sectors to identify the most promising business ideas best suited for productive use. By combining the underlying Business Model Canvas (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 to the topic, allowing practical examples to be demonstrated.

Experts eventually evaluated the business model ideas based on thirteen criteria[1]. 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 (2000) in "Quantitative Country Risk Assessment".

Framework

The development of sustainable business models is becoming increasingly essential to improve resource efficiency and efforts to counteract climate change (Münger, 2021). Sustainable business models potentially lead to new green jobs, stable GDP growth, a reduction of resource extractions, and environmental impacts (Colombo et al., 2021). Therefore, the within this paper identified sustainable business model ideas based on the BMC by Osterwalder & Pigneur (2009), integrate a circular economy aspect, as proposed by Münger (2021). **Figure 1** 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.

[1] 1) Access (difficulty and limitations) to required resources, 2) Amount of capital required, 3) Benefit for economy, 4) Benefit for end consumers, 5) Benefit for environment, 6) Benefit for society, 7) Complexity of technology, 8) Coverage of circular economy aspects, 9) External restrictions (e.g. legal), 10) Necessity of the business idea for the market, 11) Need for know-how, 12) Profitability, 13) Use of energy from renewable resources.

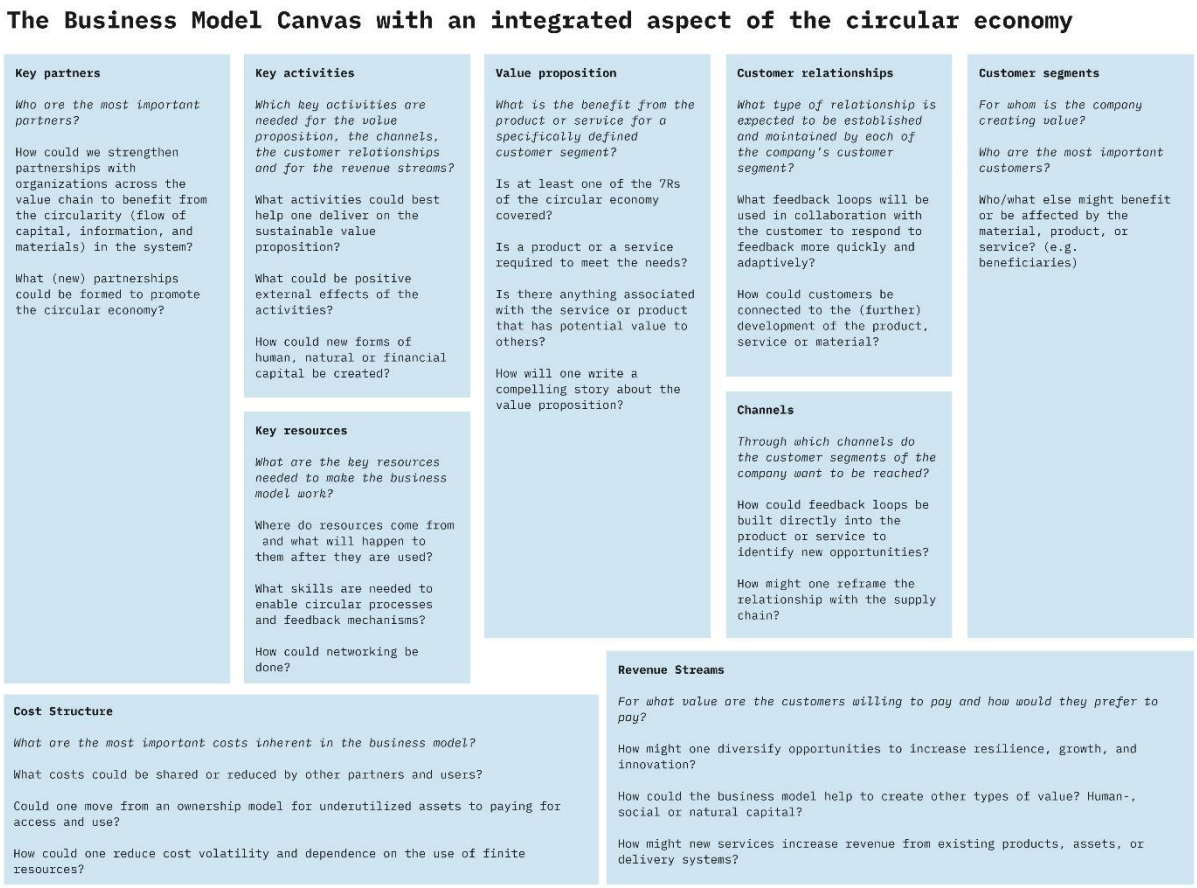

Figure 1 Circular Business Model Canvas (own illustration, based on Osterwalder & Pigneur (2009) and Münger (2021))

(PHL). In SSA, PHL accounts for 30 % to 50 % of production and thus strongly influences productivity. Often, a lack of refrigeration on the way from farmer to market is to blame for crops spoiling (World Economic Forum, 2021). In recent years, warming in Namibia has been higher than the global average (The World Bank Group, 2021a). High temperatures with an increasing trend pose a major threat to perishable foods and other items in need of refrigeration.

In fact, the volume of food losses over ten years exceeded the value of total food aid received (World Economic Forum, 2021). Lastly, farmers in SSA are mostly not integrated into regional and global value chains (Shimeles et al., 2018), hence receive only a little economic return. Around 70 % of the world's harvested coffee is exported to industrialized countries for further processing, as coffee-producing countries such as Rwanda and Uganda often lack processing and logistics facilities (Majeed et al., 2022).

Energy

Access to electricity is a common problem in SSA. Over 80 % of the population relies on plant/animal residues or wood to meet their energy needs (World Economic Forum, 2021). Namibia's existing resources do not achieve one-third of its energy needs. More than 50 % of its electricity is imported from neighboring countries and the Southern African Power Pool. Yet, only slightly more than half of its population had access to electricity in 2019, with the rural population estimated to account for less than 10 %. However, Namibia has great potential to generate its own electricity from solar energy (Hoeck et al., 2021; The World Bank Group, 2021a). One of the lowest electricity consumption rates per capita in the central-east African region is found in Rwanda. Only 37.8 % of the population had access to electricity in 2019 (The World Bank Group, 2021b). Senegal also struggles with a lack of energy. Almost 60 % of the rural population still has no access to the national power grid. However, similar to Namibia, Senegal has a high potential for solar power (KfW, n.d.). Ultimately, the AVSI Foundation's Productive Use of Electricity program in Uganda found that for 77 % of micro, small and medium enterprises, access to electricity is the most frequently cited barrier to business growth (AVSI, 2019).

E-waste

The amount of electronic waste (e-waste) is growing – both by imports of used electronics from the Global North and by domestically produced electronics used by the growing African population (World Economic Forum, 2021; Maes & Preston-Whyte, 2022). 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 in order to make the products more affordable (Leacock, 2021). In Uganda, an estimated 17,000 tons of e-waste was produced in 2018 (Bodawerk, n.d.).

Transport infrastructure

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, congestion, lack of credit, poor organization, corruption, theft, and the climate (Bogner & Hertzberg, 2022b). The continent has the world's worst road network (Bogner & Hertzberg, 2021). Such inefficient African logistics make the goods produced more expensive, so they cannot compete globally (Bogner & Hertzberg, 2022b). Delivery is, however, the core success factor of online retailing (Heinemann, 2022). As e-commerce grows, so does the demand for delivery services. However, these services are often executed by small vehicles such as motorcycles that transport less (Boateng et al., 2022). Furthermore, errors often occur in the last mile (Heinemann, 2022) 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 (Alharbi et al., 2022).

In Rwanda, motorcycles make up more than half of all vehicles on the roads, while in East Africa alone, they carry about 100 million people daily. However, in addition to the emissions they cause, they are not cheap to buy, and the fuel they require is expensive (Ampersand, n.d.b). The transport sector is the main contributor to urban air pollution in Rwanda and is insufficient to meet peak demand (SSATP, 2018). Senegal is also struggling with such problems, as many businesspeople commute daily to Dakar. Due to outdated public transportation and poor road conditions, travel time to work is often unnecessarily long (The World Bank Group, 2016), and the delivery of goods is hindered by heavy traffic congestion. According to estimates, the prevailing poor infrastructure costs Senegal about 4.6 % of its annual GDP (International Finance Corporation, n.d.). Lastly, 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 (Boisson et al., 2022). In medical transportation, cold chains must not be interrupted, but distances in SSA are often long and lack electricity access (Buitendach et al., 2019).

Health

Chronic viral hepatitis B (HBV) affects over 60 million people in SSA. An infant has a 70 % to 90 % chance of developing chronic HBV if infected at birth. Around 20 % of sub-Saharan countries (including Namibia and Senegal) have included the birth dose of HBV vaccine in their immunization schedule, with an increasing trend. The birth dose is the most effective (95 %) prevention measure against mother-to-child transmission when administered within one day after birth. However, reaching infants born outside health facilities is an everyday challenge. Ensuring the continuity of the cold chain is another major obstacle, as stated above (Boisson et al., 2022). Although mass immunization has been carried out in SSA for over five decades, the cold chain is still poorly developed and highly vulnerable to unforeseen disruptions (Buitendach et al., 2019). Furthermore, the vaccine documentation is suboptimal across Africa, while, contrary to many assumptions, the vaccine cost is not an issue (Boisson et al., 2022). In addition to chronic HBV, the continent also struggles with other diseases. In Namibia, HIV/AIDS, malaria, tuberculosis, diarrhea, and pneumonia are the top five causes of inpatient deaths for all age groups. Moreover, the continents (rural) population is increasingly threatened by vector-borne and waterborne diseases such as lymphatic filariasis, cholera, and yellow and dengue fever due to climate change (The World Bank Group, 2021a).

Promising business ideas for overcoming mentioned challenges.

1.1 Solar-powered walk-in cooling stations

The PHL challenge (see chapter 4.1) can be significantly reduced by using solar-powered cold storage. Such a room provided by the Nigerian company ColdHubs contains 120-mm-thick insulating panels. It needs an inverter and high-power batteries to keep energy from the roof-mounted solar cells (ColdHubs, n.d.). As the cost of solar

technology has declined recently, the potential of reaching economic viability for such solutions in poor, primarily rural areas rise (Takeshima et al., 2021) and brings social benefits. Introducing solar-powered appliances in off-grid areas significantly reduces the disparity between urban and rural areas (Global Ice Tec AG, n.d.). ColdHubs offers stationary solar refrigeration of perishable food, and with it allows shelf life to be extended from two to 21 days, resulting in an 80 % reduction in PHL. Additionally, farmers can increase their annual income by 25 % by being able to sell more of their harvest. To use the hub, they pay a flat daily fee for each crate stored based on a pay-as-you-store subscription model (ColdHubs, n.d.). However, the lack of experience of insurance companies with these business models can be seen as a hurdle, as it is challenging to obtain insurance coverage (World Economic Forum, 2021).

Aquaponics

Aquaponics, an integrated closed loop system that combines hydroponics with aquaculture, is one of the most efficient ways to address challenges in SSA sustainably (Obirikorang et al., 2021; Tyson et al., 2011). Accordingly, both plants (specifically leafy vegetables (Goddek et al., 2019)) and fish are produced from one water source (Tyson et al., 2011) through the usage of fish waste as a fertilizer. Solely fish feed and supplements are added to the system (Goddek et al., 2019). Solar energy can additionally be used to pump water into the system and for temperature control (World Economic Forum, 2021).

Aquaponic systems are vital in SSA, not least because of vegetables but also because fish is critical to improving malnutrition and, eventually, the export business (Obirikorang et al., 2021). In fact, Namibia is one of the world's most productive fishing areas (The World Bank Group, 2021a), and in Senegal, fishing is the second largest source of income and employer (The World Bank Group, 2011). Uganda's fish farming represents the second largest export earner (The World Bank Group, 2021c). The demand for fish continues to increase, making aquaculture the fastest-growing global food production sector (Goddek et al., 2019).

However, fishing is increasingly threatened by climate change and burdened by increasing fishing efforts, which puts severe pressure on capture fisheries, leading to fish shortages and destructive fishing techniques (The World Bank Group, 2021c).

Although aquaponics systems have high startup costs, their potential to become economically viable when operated with local materials is high. After deducting operating expenses, profits are about 30 times higher than in traditional agriculture due to more efficient land use, fish income, and year-round cultivation. Furthermore, a Kenyan market study found that African customers are willing to pay more for aquaponics products because they are healthier, fresher, and pesticide-free (Obirikorang et al., 2021). Being a soil-less system, aquaponics is moreover independent of location and soil availability, thus can be used in urban areas or on unused or

underutilized land. From a sustainable perspective, the water footprint of aquaponics systems is significantly better than traditional agricultures. Regions suffering from water scarcity will particularly benefit from aquaponics technology being operated in a commercial setting (Goddek et al., 2019).

E-Boda-Boda

Motorcycles, called Boda-Bodas in East Africa (W.L Ntshinga et al., 2012), can serve as a sustainable solution to the existing traffic problem described in chapter 4.4. Ampersand is already a leading company offering an energy solution for electric Boda-Bodas (e-Boda-Bodas) and transportation (Ampersand, n.d.a). Its business model provides both a service and a product since customers can buy or lease an e-Boda-Boda, with both options managed via the pay-as-you-drive method. According to this method, payment is made for the energy consumed (Ampersand, n.d.c).

The usage of e-Boda-Bodas is indeed relatively sustainable as they emit 75 % fewer greenhouse emissions during their lifecycle than petrol motorcycles using grid power. Using renewable energy to recharge batteries makes transportation even more sustainable. If all Boda-Bodas in Kigali (about 300,000) were electrified, one could save 157,000 tons of CO_2 emissions per year. Furthermore, e-Boda-Bodas are economically beneficial for the driver since being less expensive to purchase, maintain and operate than a fuel vehicle. An Ampersand driver spends 3.51 USD on energy per day, whereas a petrol driver spends 4.68 USD on fuel per day. This, in turn, leads to higher revenue for the e-Boda-Boda driver at the end of the day (Ampersand, n.d.b). Ultimately, the ultra-high lifecycle lithium batteries have a range of 60 km to 90 km and must be replaced less frequently than drivers typically refuel (Ampersand, n.d.c).

E-waste energy storage

91 % of micro, small and medium enterprise respondents to the Productive Use of Electricity program in Uganda already use solar energy and own the panels (AVSI, 2019), showing that photovoltaic (PV) is becoming increasingly important for energy supply in rural SSA (Charles et al., 2019). Battery-powered energy storage systems based on lithium-ion technology can be used to enable households and enterprises that already have solar systems to use the power they generate, further improving access to electricity.

For these systems, the cost of batteries accounts for 81 % to 93 % of the total storage system costs (Charles et al., 2019). 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 (Charles et al., 2019). A suitable battery pack for this household should offer a capacity of about 2,000 Wh.

A commonly found lithium-ion cell is the Panasonic NCR18650B-3, which has a measured capacity of 11.33 Wh (Muenzel et al., 2015). Assuming a degradation of 20 % of its capacity through prior use results in a remaining

capacity of 9.064 $\frac{Wh}{cell}$. Using this type of battery, the needed number of e-waste cells are $\frac{2{,}000\ Wh}{9.064\ Wh/cell} = 220.65\ cells \rightarrow 221\ cells$, 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 (Charles et al., 2019).

Hemp

The African hemp industry is growing faster than any other industry. Ten times more legal cannabis was exported in 2021 than 2020 (over 15 tons), mainly from South Africa, Uganda, and Lesotho (Schlindwein, 2022b). It is estimated that at least 38,000 tons of African cannabis are produced annually (Prohibition Partners, 2019). The increase may be because cannabis is relatively easy to cultivate in some African countries, for example, in mountainous regions with rich, fertile soil with harvesting seasons every three to four months (Prohibition Partners, 2019). The advantage of growing on the equator is that less energy is needed, leading to fewer costs, which makes the end product cheaper (Schlindwein, 2022c). Moreover, hemp is generally more lucrative than traditional crops (e.g., sugar cane, corn). In Congo, for example, 100 kilograms of cannabis can sell for between 96 USD and 128 USD, while the exact weight of corn fetches only 54 USD (Prohibition Partners, 2019). However, import regulations to Europe are costly (Schlindwein, 2022a). In Uganda, an export license costs 5 million USD (Schlindwein, 2022c). From a sustainable perspective, hemp farming is advantageous. One hectare of hemp can absorb more carbon dioxide from the atmosphere than regular greenery (Deutschlandfunk, 2022). And one kilogram of hemp grown indoors consumes up to five tons of CO_2 (Schlindwein, 2022b).

The market for hemp fiber is relatively large as it can be used for 22,000 industrial purposes (Deutschlandfunk, 2022). Due to its high wet strength, it serves as a raw material for ropes, cordage, and textiles. Hemp can also be used for paper production, 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 (Diepenbrock et al., 2012). Thus, attention would have to be paid to keep the value chain in Africa (Schlindwein, 2022b).

RE-Commerce

To exploit the potential of e-commerce in Africa, business ideas are needed. As e-commerce is prevalent among Generation Z (Heinemann, 2022), such business models would indeed benefit from Africa's young, digitalized generation. 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 (Odonkor, 2020). Since 2014, the number of African online shoppers has been increasing by 6 % more than the average growth rate globally (United Nations, 2018). From

a social perspective, e-commerce could reduce inequalities by providing rural customers with the variety, convenience, and low prices that urban residents already enjoy (The World Bank Group, 2019). In many countries, such as Rwanda, e-commerce is not yet commonly used, providing a competitive advantage for companies who could potentially benefit from a forecasted Rwandan market volume of 728 million USD in 2025 (Bogner & Hertzberg, 2022c).

To further strengthen the sustainable aspect of the business model idea of e-commerce, one could consider establishing a second-hand platform for SSA. A business model under the umbrella term of RE-commerce (short for re-use), which is attested to be promising by experts. This would enable price advantages for a more extensive customer base and halt further resource extraction (Heinemann, 2022). In fact, considering second-hand fashion, Africa is already at the forefront of establishing a circular fashion industry (World Economic Forum, 2021).

E-waste solar power banks and flashlights

African countries are pioneering efforts to reduce e-waste by adopting policies, regulations, and laws (including extended producer responsibility) (Lebbie et al., 2021). In addition to preventing damage to health through proper recycling, the recovery of expensive and scarce materials from e-waste through collection and recycling represents a promising economic opportunity. The value of raw materials in Africa's e-waste is about 3.2 billion USD (World Economic Forum, 2021). Bodawerk International Ltd. (Uganda) already manages African waste. The company uses old lithium-ion cells from broken power tools, laptops, and other devices to produce and sell flashlights and power banks with an integrated flashlight (Bodawerk, n.d.). In addition to the sales model, the social enterprise WeTu (Kenya) offers a leasing model, which leases solar lights to fishers in the shore areas of Lake Victoria (Global LEAP Awards, 2021). The production costs of an e-waste solar power bank with an integrated flashlight with a capacity of 20,000 mAh can be calculated using the widespread 18650 battery format used worldwide in laptop batteries and power tools (Muenzel et al., 2015). Using the same Panasonic NCR18650B-3 as in chapter 5.4, the remaining capacity of the cell after a 20 % degradation through prior use is 9.064 $\frac{Wh}{cell}$. 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 are $\frac{72\ Wh}{9.064\ Wh/cell} = 7.94\ cells \rightarrow 8\ cells$. 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 $8\ cells * 1.50 \frac{EUR}{cell} = 12\ EUR$ (not including housing, charging electronics, LED, production, and packaging). This business idea not only addresses the problem of e-waste, but also provides affordable access to power and light.

E-crowd logistics

In addition to existing e-logistics platforms in SSA, crowd-logistics services for last-mile deliveries and city distribution are a promising concept (Buldeo Rai et al., 2017) with a huge market potential (Agyemang, 2022).

Crowd logistics allows commuters who use public transportation to transport packages on their way (Buldeo Rai et al., 2017) or to give a lift to other people (Alharbi et al., 2022). Whether transporting passengers or packages, this service brings social, economic, and environmental benefits. The reduction of traffic, emissions, and resources count for ecological benefits. In contrast, the linkage of rural communities to a broader range of products and overall logistic efficiency, including the reduction of last-mile errors, are social and economic advantages (Buldeo Rai et al., 2017). In terms of enterprises, benefits include a large area, a flexible workforce, and no investment in employees or a vehicle fleet (Buldeo Rai et al., 2017). Conversely, the crowd is motivated by supplementary earning opportunities that are adaptable and individualized to their lifestyle (Buldeo Rai et al., 2017). A study in Ghana found that people are indeed willing to accept the concept of crowd logistics and participate in its implementation (Zalia et al., 2021), and the population density in cities secures the availability of a critical mass required for crowd logistics platforms (City Logistics, 2018). Despite the supporting factors, the concept also encounters barriers in the form of theft, loss, damage, and privacy concerns. To counteract this, feedback and secure online payment systems need to be included (Buldeo Rai et al., 2017). Moreover, an African logistics entrepreneur came up with the idea to solely run his company by women after discovering that it is mainly men who steal products (Bogner & Hertzberg, 2022a). To implement the concept, a technological infrastructure in the form of an accessible platform is needed to coordinate logistics services' supply and demand (Buldeo Rai et al., 2017). Fortunately, Africa's ICT infrastructure is steadily growing, with a current Internet penetration of 32.4 % (Agyemang, 2022). Senegal is increasingly positioning itself as a leading provider of ICT and teleservices in SSA (Ndiaye, 2020). Also, Rwanda is a pioneer of digitalization (Bogner & Hertzberg, 2021), and Namibia's telecommunications service was ranked as the best in Africa (Namibian Government Portal, n.d.).

Solar coffee roasting

African coffee-producing countries lack processing facilities to generate value within the country. A relatively cheap (concerning production costs) and sustainable solution is using a solar-based oven to process harvested beans. Apart from coffee beans, a group of reflectors, a roasting drum, and a control unit are required for such a system. No external energy is needed, as the mirror is autonomous and powered directly by sunlight, leading to high system reliability (PuroSole, 2021a).

The Italian startup PuroSole has already recognized and seized this opportunity. It produces up to 300 kilos of roasted coffee on a sunny day without emissions and conventional energy consumption. Mirrors focus the sun's rays on reaching temperatures of 200 °C to 300 °C. This process is beneficial as the beans are not burned as much by the shorter roasting and can retain their ingredients better (PuroSole, 2021b). For every 1,000 kg of coffee roasted with the sun compared to the processes using gas, the production, and release of over 400 kg

CO_2 into the atmosphere is avoided (PuroSole, 2021b). Furthermore, using solar energy can enable an annual saving of about 60,000 kWh for producing 30,000 kg of coffee (PuroSole, 2021a).

However, the roasting process requires constant illumination, limiting the process to days with clear skies. Each coffee bean must be directly illuminated cyclically and simultaneously from a different angle (PuroSole, 2021b). Advantageously, the potential of solar thermal energy is vast in SSA. The roasting of coffee beans and other agricultural products is promising since the daily average direct normal irradiance ranges from 5.5 to 7.5 kWh/m^2 with annual sunshine of more than 300 days (Majeed et al., 2022). In comparison, in Germany, it is between about 2.3 and 3.2 kWh/m^2 (Solargis, n.d.).

Last-mile agile cold-chain transportation service platform for vaccinations using portable cool boxes.

The global market for cold transportation solutions is increasing, with managing transportation alone is worth over 13 billion USD in 2017, while growing 5 % to 6 % p.a. (Ogwengo, 2020). In that regard, Boisson et al. (2022) suggests focusing on community-level interventions, especially in rural areas to eventually overcome vaccination transportation issues. Buitendach et al. (2019) present a suitable PV-based cooling box for vaccine cooling and storage. The box holds ten liters and can store up to 250 vials of vaccines at a temperature of 2 °C to 8 °C. As the cooler is sturdy and user-friendly, maintenance costs are minimal (Buitendach et al., 2019). Moreover, the Kenyan company Twiga Foods offers a business-to-business (B2B) e-commerce food supply platform (World Economic Forum, 2021), which could also be put in use to the vaccination problem. This business model idea could be applied to the vaccination problem and offer a last-mile agile cold-chain transportation service platform that brings together health facilities on the one hand and those in need as well as health community workers and vetted individuals on the other. Health community workers and vetted individuals serve as intermediaries to deliver the medical goods or vaccines using solar-powered portable cool boxes. In addition to platform maintenance and customer support, such platform operators communicate the importance of vaccinations and educate people accordingly.

Results

Table 1 summarizes the business model ideas to address the challenges named above. The ranking was performed using fuzzy logic with artificial intelligence, based on the system for exploring country risks proposed by Steurer (2000). Ranked first was the 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). These ten business model ideas can be categorized into three overarching areas: sustainable agriculture, renewable energy, and ICT. The

results demonstrate that the easier (i.e., the higher the value; highlighted in green) the access to required resources, the better the business model idea was perceived. This also applies to the evaluation criteria amount of capital required: the lower the capital requirement, the higher ranked was the idea (high value; highlighted green). Additionally, a major benefit (for the economy, end consumers, environment, and society) and high degree of circularity (high 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. The low complexity of the technology required to implement the business model idea corresponded to a high value (highlighted green) and thus a better rank. The same applied to the evaluation criteria external restrictions and need for know-how. Since this paper was based on a qualitative literature review, the criterion profitability was evaluated just on a qualitatively basis. The more profitable an idea was evaluated, the better it ranked.

--- Table 1 ---

Discussion

Based on the results, the defined research question 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 the business model ideas is ***value delivery***. Accordingly, a major advantage implies an excellent value delivery. The second prerequisite is ***promising customers***, which is 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. This suggests that business models addressing health issues such as chronic HBV tend to have more customers. 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 fourth prerequisite is the ***presence of key resources***, defined by the access (difficulty and limitation) to the resources required. Ease of access represents a more secure presence of critical resources, 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 countries such as Senegal and Namibia is high. 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 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 knowledge represent an easy way to carry out key activities. Since this paper focuses on implementing sustainable business model ideas, s***ustainability*** is the sixth prerequisite defined by the degree of circularity and the usage of renewable energy. The more the concept of circular economy and energy from renewable sources is used, the more sustainable the business model ideas become. ***Profitability***, defined by qualitative reasoning, can be identified as the seventh prerequisite.

Moreover, the canvas building blocks key partners, customer segments and relationships, channels, cost structure, or revenue streams influence the identified prerequisites. For instance, key partners committed to the environment can positively affect fulfilling sustainability.

However, not all prerequisites and business model ideas are equally easy to fulfill and equally promising for productive use in SSA. For example, the business model of 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 the sustainability prerequisite and the presence of key resources prerequisite due to logistical challenges.

The analysis also identified business model ideas for which the prerequisites are equally easy to fulfill and equally promising in all countries, which, for example, includes aquaponics. As reflected in the literature review, more than half of the population in SSA is employed in the agricultural sector. Therefore, promoting ideas for the primary industry and increasing its productivity is essential. Due to the overall population increase in SSA, demand and thus the customer base for agricultural products is steadily growing. However, climate change more and more stresses the work of farmers. Here, aquaponics can offer excellent benefit as a sustainable solution for the agricultural sector, as outlined in chapter 5.2. The concept also reduces logistics costs, as food can be cultivated directly in urban areas rather than being confined to rural areas. Thus, this factor positively impacts the precondition 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.

Finally, it bears noting that women in Africa, as described at the outset, play a critical role in boosting the economy, reducing poverty, and improving living standards. Therefore, the role of women must be firmly taken into account when realizing described business ideas.

Conclusion and limitations

The overall purpose of this paper was to identify and define prerequisites for the successful implementation of sustainable business model ideas in SSA by developing ten ranked business model ideas that are best suited for

productive use in SSA, thereby increasing economic growth and reducing poverty and inequality. Five current challenges in SSA were considered: agriculture, energy, e-waste, transport infrastructure and health. Agriculture, renewable energy, and ICT were found to be the most promising sectors for the ten sustainable business model ideas. Moreover, seven prerequisites for the successful implementation of these ideas were identified and defined: value delivery, promising customers, sufficient capital, presence of key resources, possibility to perform the key activities, sustainability, and profitability. It has also become apparent that not for all business model ideas the prerequisites are equally easy to fulfill in all countries and the ideas are not equally promising in SSA. However, this should not be seen as an obstacle given that the potential of SSA, with its natural resources and large working-age population, is vast 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.

This paper was based on a comprehensive literature review that implies two major limitations. First, the categorization of the information is necessarily 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 study, future research could empirically assess the applicability of the proposed business model ideas and the prerequisites derived from them by focusing on local surveys.

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Evaluation criteria \ Business Models	Aquaponics	E-Boda-Boda	E-crowd logistics	E-waste energy storage	E-waste solar power banks & 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 1 Ranked business model ideas (own illustration)