

Emerging bioeconomy opportunities in Africa

A case study of *Croton megalocarpus* Hutch in Kenya

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1. Introduction

The Bioeconomy has multiple definitions and objectives but a key aspect is its focus on the production of biomass and its uses beyond energy, food, feed and fibre products to produce products with value-added, as well as improved or new supply chains. States in sub-Saharan Africa have started to look at the potential for the bioeconomy to add value to their bioresources and biowaste. However, there is a difference from European bioeconomy goals, which focus on high-value molecules and have a clear objective of reducing greenhouse gas emissions through the use of alternative non-fossil fuel products. The bioeconomy can drive innovation in different areas of the biosciences, and in the green and circular economy. Complementary aims of the bioeconomy are capacity building, improved agriculture, improved well-being and an enhanced gender balance.

The emerging bioeconomy in Africa sparked considerable interest in biofuels as oil prices rose at the start of the new millennium but development stalled following the financial crisis of 2008. Various organizations and studies examined the potential for the biofuels sector to achieve sustainable development through the Millennium Development Goals (MDGs), in particular those on poverty reduction and achieving zero hunger. Later, the focus has been on the Sustainable Development Goals (SDGs), such as SDG1 on ending poverty, SDG2 on food security and SDG 7 on energy access (see Rosillo-Calle and Johnson 2010; Diaz-Chavez 2011; Janssen and Rutz 2012). The benefits and potential development impacts of these goals, however, have been questioned (Vermeulen and Cotula 2010; Schoneveld et al. 2011). In addition, few studies have looked beyond the production of a single product, notably biofuels.

In sub-Saharan Africa, natural resources that can contribute to the expansion of the bioeconomy cut across the traditional economic sectors, while also contributing to the achievement of multiple SDGs at the regional and local levels. Oil-producing plants such as oil palm and croton have been used for centuries on a small scale. Others, such as groundnuts, moringa or sesame seeds, were introduced later.

In East Africa, the croton tree *Croton megalocarpus* Hutchinson demonstrates the potential of the bioeconomy. A programme funded by the International Fund for Agricultural Development (IFAD) and the International Centre for Research in Agroforestry (ICRAF) on the development of alternative biofuel crops (DABC) ran from 2013 to 2016. It aimed to develop biofuels through pro-poor models that met local socio-economic need, empowered women and contributed to rural development while benefiting the environment. The programme was implemented by ICRAF in a partnership with the Eco Fuels Kenya (EFK) Group. The project contributed by assessing the sustainability of the croton value chain in Kenya and addressing research gaps to support its upscaling and ensure that the livelihoods of rural people were enhanced (Ciannella 2016).

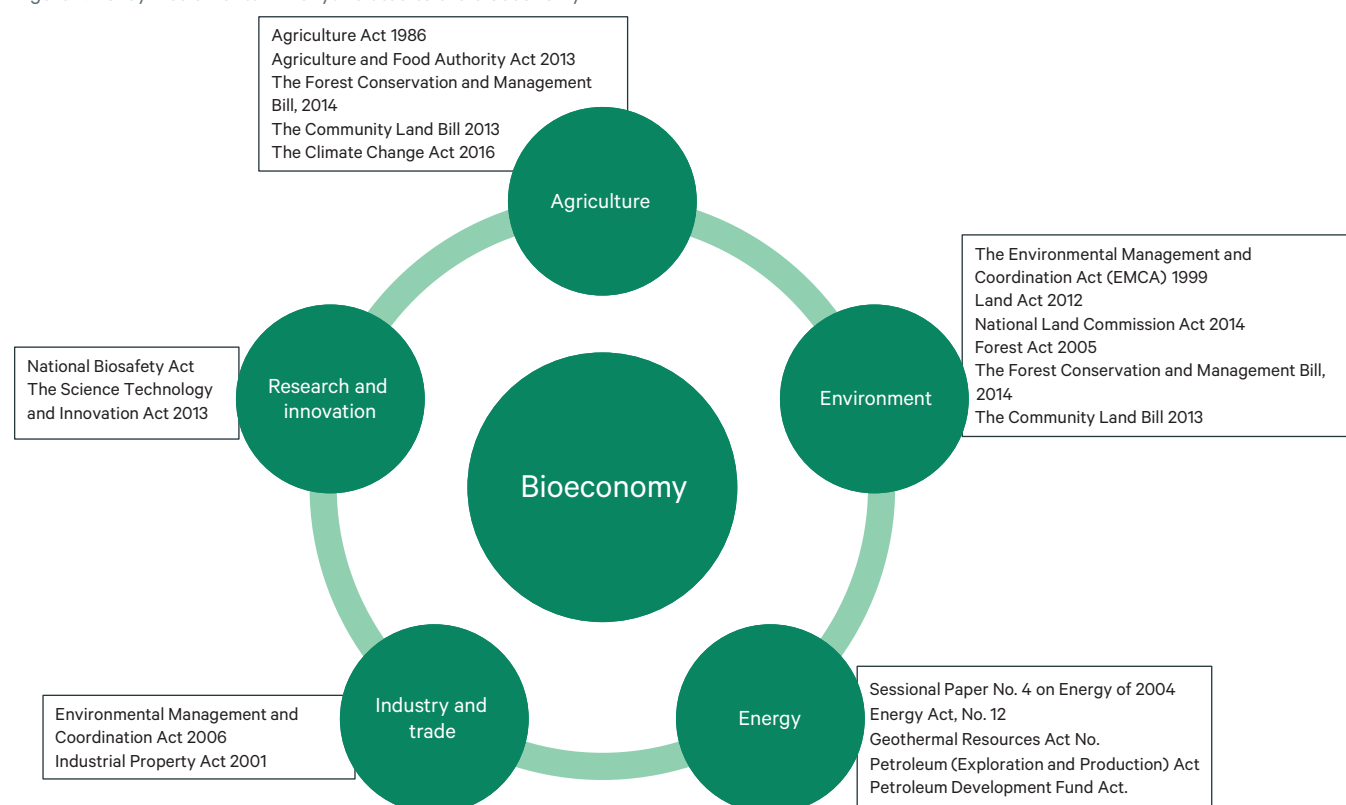
Several studies have been conducted in Kenya on the value chain of *Croton megalocarpus* Hutch (Jacobson et al. 2018; Ciannella 2016). The main focus of these studies was the production of biofuel and the links to improving livelihoods. This brief focuses on the value added by this natural resource from a bioeconomy perspective, which includes the potential for several croton products to improve farmers' livelihoods and contribute to several economic sectors in the region.

The study focuses on one company's business model (EFK) based on *Croton megalocarpus*, and the value chain it has developed in Kenya. In-depth interviews were carried out with EFK staff, farmers, the government representative in the local area and ICRAF. The farmers, who are part of the company business model, explained how the bioeconomy works in practice by providing them with additional income. The government representative provided information about the status of current policy and the benefits that might occur at the local and regional levels. Representatives of ICRAF discussed the policy framework, their understanding of the development potential of croton and the opportunities for scaling up. The case study also identified six sustainability indicators that can provide some insights into the potential of the bioeconomy in the region.

2. Bioeconomy policy context in Kenya

There is currently no overall bioeconomy or bioenergy strategy, plan or policy in Kenya. Instead, several policy and regulatory instruments are in place that could support bioeconomy development (see Figure 1). The current policy and regulatory system does not contain a system of incentives that can foster the wider development of a bioeconomy.

Figure 1. Policy instruments in Kenya related to the bioeconomy



Source: Author's own design

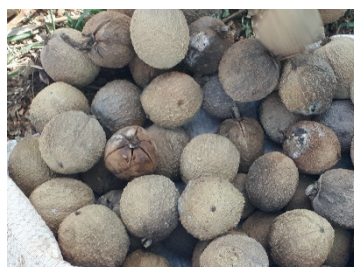
Nevertheless, the BiSEA project funded by Bioinnovate has been working on a regional Strategy for Bioeconomy in Eastern Africa including Kenya (EASTECO, 2020).

At the local level, the Director of Environment in Nanyuki County indicated that one of the main problems the county faces is land degradation. The county therefore has an afforestation programme, which makes the activities of EFK in promoting the planting of trees very welcome. Local government sees it as important to map the biological resources of the county in order to have better information on how to support local policy, to help the government understand the value of its resources and to provide better opportunities for local communities (Interview, David King'ori 2019).

3. The use of *Croton megalocarpus* Hutch

Croton megalocarpus Hutch is a member of the Euphorbiaceae family and is indigenous to eight states in East and Southern Africa: Burundi, the Democratic Republic of the Congo, Kenya, Malawi, Mozambique, Rwanda, Tanzania and Uganda (Chudnoff, 1984). It is a fast-growing canopy tree that grows to a height of up to 36 metres. It matures after 5–7 years and has a lifespan of up to 70 years (Orwa et al. 2009). It is a drought resistant tree species and inedible for humans and animals alike.

Figure 2. Croton fruits and tree in Nanyuki



Photos © Diaz-Chavez

According to Wu et al. (2012), the fruits of *Croton megalocarpus* are a promising biofuel resource in Africa with much greater oil production potential than *Jatropha curcas*. Croton seeds contain almost 32% oil content, which can be extracted either mechanically or using chemical solvents (Jacobson et al. 2018). It has been reported that the oil can be used in diesel stationary engines such as generators and in irrigation pumps, as biodiesel, for medical purposes and to feed poultry.

At the farm level, croton trees have traditionally been planted mainly as live fences to provide shade and fuel wood. The fruits are left on the ground or used to feed poultry during the dry season. Several farmers indicated during the interviews that until they heard about the possibility of selling the fruits, they used to cut branches for fuel wood and leave the fruits on the ground to rot (Interviews, David and Godfried 2019).

4. EFK and the croton value chain in Kenya

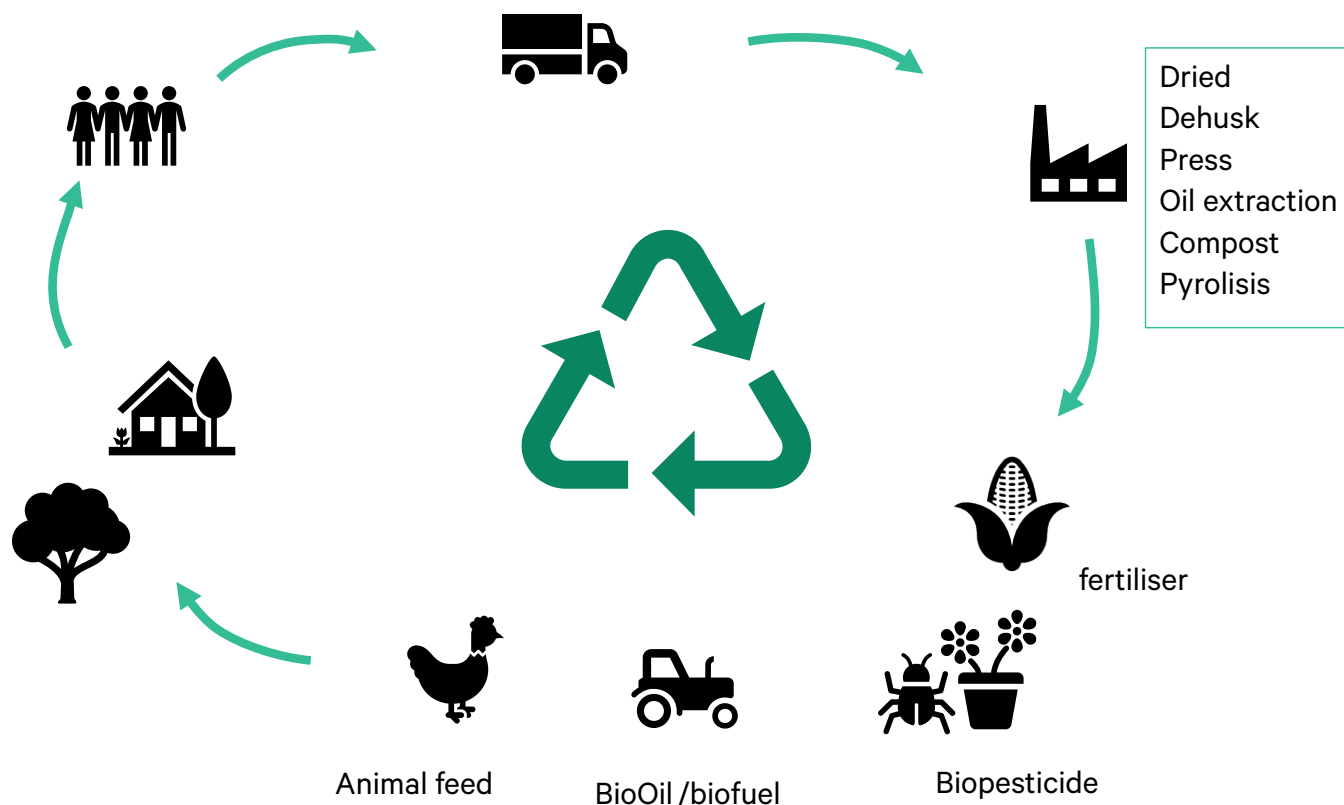
EFK was the first company in Kenya to undertake research and development on bio-products derived from *Croton megalocarpus* oil and the markets for these products. The company was established in Nyeri County in 2012 but later relocated to Nanyuki County. EFK purchases croton nuts from over 5000 subsistence farmers across Kenya, thereby providing an important source of farm income each year. Croton fruit processing yields several products which the company has expanded into since its inception, moving away from the sole production of oil as biofuel.

The operation was begun as an initiative of a Dutch company, Biodiesel Professionals, which set up in Nyeri in 2010 to produce and refine oil from croton. The current company was set up in 2012 with an original investment of US\$ 50,000 and an additional equity loan of US\$ 50,000. Additional loans and grants have been used to maintain continuous operation, to expand staff numbers and for new research. Dubai Export funded research on products in 2018–19. The MEDA organization (2019) helped to improve the supply chain in Samburu, Makuei and Bonnet counties in 2019–20 (Interview, Moses Waweru 2019). The company was originally expected to become profitable by the end of its third year, but this has taken longer to achieve. Profitability is now expected after 2020. The company continues to apply for grants from international organizations (Interview, Cosmas Ochieng 2019)

The company has 29 permanent members of staff, including its managers. Their salaries range from a minimum of KES 13,000/month to KES 16,100/month. During the high season, the permanent production workforce is supplemented by casual staff. This fluctuates between 2 and 4 extra workers per week. In the high season the company operates three shifts and staff work a 45-hour week (Interview, Alex Ng'ang'a 2019). The research department assists by making applications for grants and other funds to help maintain a 24-hour operation. It also conducts surveys of farmers to gather socio-economic data and calculates the footprint of the company using a life cycle assessment (LCA) methodology (Interview, Faith Mukami 2019). The research department is also preparing to implement Access Benefits Sharing (ABS) under the Nagoya Protocol (CBD, 2019), which will mean working with government and local communities on indigenous products in the bioeconomy.

The stages of the company's value chain are shown in Figure 3. Farmers enter into an agreement with the company to collect the croton fruits. The fruits were previously wasted as only a few farmers fed them to poultry during the dry season (Interview, Emmanuel Kamali 2019). The fruits are transported to the company, which offers a collection service through its agents. Once delivered, the fruits are first dried and then de-husked. The nuts (or seeds) are pressed to extract the oil, which is sold as biofuel to be used in machinery such as tractors and generators. The cake that results from the oil extraction is processed for use as poultry feed while the shells are mixed with cake from the extraction in order to compost them to produce fertiliser that is sold to vegetable and flower producers in the region. The remaining compost is processed through pyrolysis to produce a vinegar that is sold as a biopesticide (Interview, Alex Ng'ang'a 2019).

Figure 3. EFK value chain



Source: Author's own design

The products that result from processing and the inputs into the Croton supply chain are shown in Figure 3. Production is seasonal and there are two peaks: April to June and September to November. The company has a contingency plan for the low season, which entails the storage of dried croton fruits (Interview, Emmanuel Kamali 2019). In 2018, a dry year affected fruit yields, which made it a difficult year for all the collectors and for EFK.

Figure 4. Processing of croton and co-products yields



Source: Author's own design

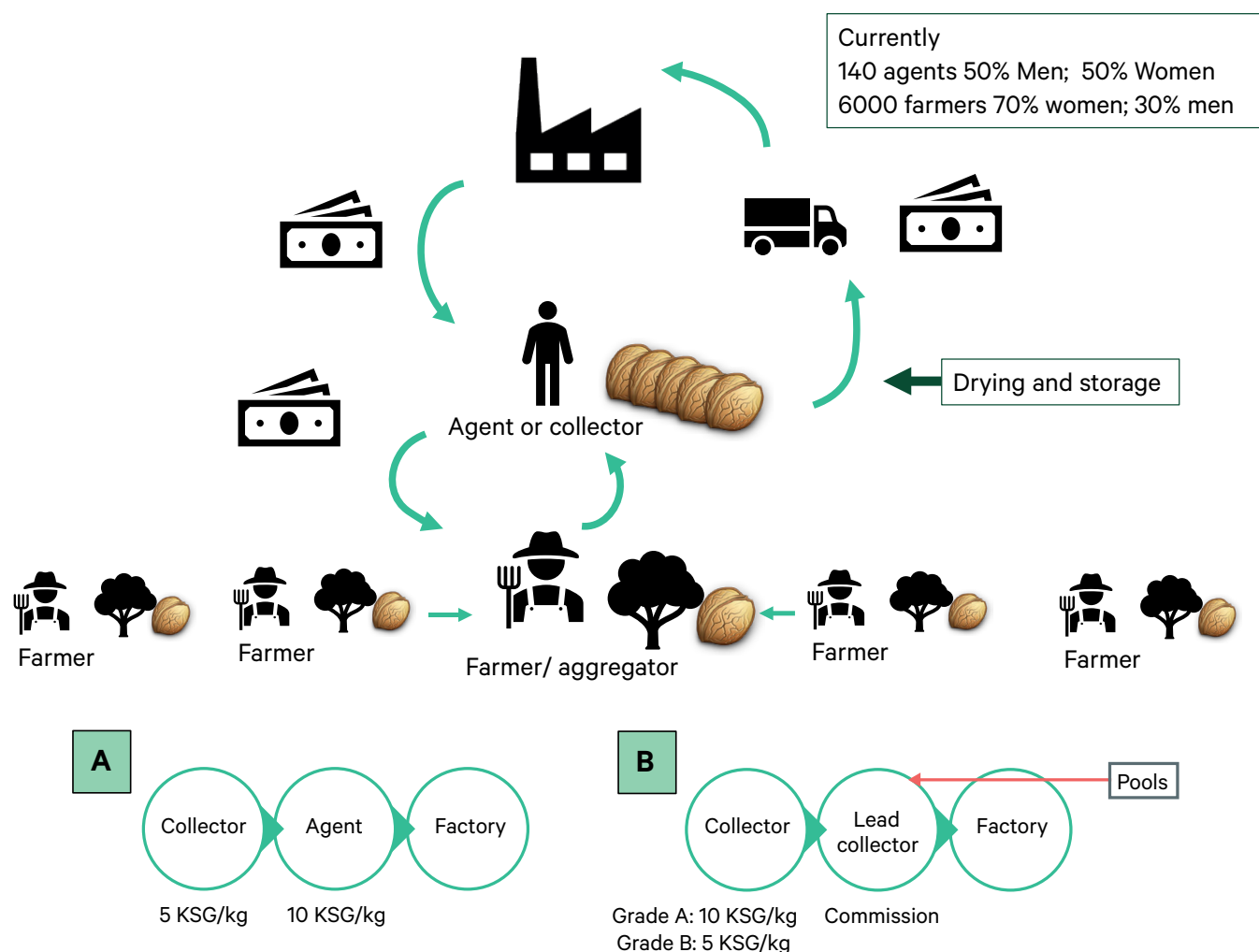
Figure 4 shows that oil production accounts for up to 10% of the nut content, while some 80% of the nuts processed ends up as organic fertilizer or poultry feed, meeting a growing demand to help Kenyan farmers adopt sustainable farming practices (EKF 2019). In high season, the factory runs on three shifts per day. The processing of 1 tonne of croton nuts requires 50KW of electricity and 150,000 litres – or two tankers – of water. The price of water is KSH 12,000 to KSH 14,000 per month, which is paid to the local council. The Operations Manager reported that water is the greatest concern in the processing (Interview, Alex Ng'ang'a 2019).

5. Business model

The company is currently operating in 17 counties in Kenya. The EFK business model starts with a programme of planting croton trees in the counties. EFK (2019) reports that it is the world's only croton nut processor, and is currently scaling-up its production of organic biofuel, animal feed and organic fertilizers to meet demand in a rapidly growing market in East Africa. In order to increase the supply base for croton in East Africa, EFK has plans to plant 300,000 trees between 2016 and 2022 (Interview, Moses Waweru 2019). This is a long-term strategy to increase forest cover, promote soil health and reduce the impacts of climate change.

The company has two business models in operation (see Figure 5), both based on the participation of agents (aggregators) and farmers (collectors). An agent collects the dried fruits from various farmers and stores them (aggregates) before they are transported to the factory. The transport is provided by EFK unless otherwise stipulated, as some farmers take them directly to the factory. EFK pays the agents who then pay the farmers. In the first model (A), the company pays the agent KES 10/kg, who pays KES 5/kg to the farmer. EKS has is testing a second model (B), where a pool of collectors sells to a lead collector who will work on commission (Interview, Emmanuel Kamali 2019). All the farmers – both collectors and agents – receive training on what EFK requires of the fruits, which should be a certain size, properly dried *in situ* and have no visible fungus infection.

Figure 5. EFK business model



Source: Author's own design

The aggregators see this is a good alternative income. For instance, one aggregator (Interview, David 2019) indicated that he has been working in the value chain for five years. He works with approximately 300 collector farmers, half of whom are women. The collectors gather around 1 tonne in 3 days and the aggregator can collect around 20 tonnes/year (Interview, Godfried 2019). With regard to the business model, a collector who has worked with the company since 2013 (Interview, Maggie 2019) indicated that she was happy with the scheme: “it is a good business for women. You just need to collect the fruits. Before we used to cut the trees, but now we prefer to keep them and sell the croton nuts”. This demonstrates the synergies of the bioeconomy with conservation objectives.

Mary (Interview 2019), another agent in Laikipia (Nanyuki), began working for the scheme in 2014. She has 500 collectors, half of whom are women. She also owns a shop and land with croton trees. In 2018 she aggregated 40 tonnes, which was a lower volume than usual due to the drought. She employs three people direct to collect the fruits she grows and pays them KES 300 per day. The additional income she receives is used for household purchases and to pay school fees.

Other farmers in Nyeri County also provided their views on the business. Tabetha (Interview 2019) is the longest serving aggregator as she has been working with the company since the beginning. She heard about the scheme on the radio and was recruited as an aggregator. Tabetha has 100 collectors (95 women and 5 men). She also has 3 acres of land, from which she collects the fruits from 20 trees. This provides approximately four 20-kg bags. She collects and dries the fruits from her own trees at home. She is happy being an aggregator: “It is a tree they planted and can collect the fruits, even the elderly can help...In the past we used the tree for firewood and charcoal. People stopped cutting them down once they knew about the activities of EFK”.

Katherine Wangeri, a collector, has been working with Tabetha since 2019. She told how “farmers always need money, and this activity provides another income” (Interview, Katherine Wangeri 2019). In 2019 she received KES 19,035 for croton nuts and she enjoys the work. A shop owner (Venanzio Gahu, Interview 2019) sells the poultry feed and the fertiliser and is also an agent, collecting from 100 people. He prefers collecting the fruits because it gives him more money than selling the products. He sells the poultry feed and fertiliser direct to other small farmers (Interview, Emmanuel Kamali 2019).

Although the evidence provided by the small number of farmers interviewed (both agents and collectors) is anecdotal, it is clear that the activity provides them with an alternative income that is separate from their traditional activities. Two of the farmers interviewed complained about the price per kilogram paid by the company, but later agreed that the effort involved in collecting the fruits is minimal, and that otherwise it would only be left to rot on the ground.

Figure 6. Collector Godfried in Nanyuki county



Source: © Diaz-Chavez 2019 with permission

Figure 7. Venanzio's shop selling fertilizer and poultry feed



Source: © Diaz-Chavez 2019 with permission

Figure 8. Katherine Wangari with stocked croton fruits



Source: © Diaz-Chavez 2019 with permission

6. Qualitative sustainability assessment using a set of indicators

EFK has been operating since 2012 but it has not been possible to obtain data about the levels of production since the company started. Nor was it possible to obtain socio-economic data from the farmers, due to the small number of interviews. The analysis below is therefore qualitative. The assessment of the selected indicators is presented as a traffic light scheme to demonstrate the opinion of the interviewees on the sustainability criteria proposed in the SEI governing the bioeconomy initiative (Diaz-Chavez et al, 2019). The data discussed above is summarized in qualitative form. Red indicates the absence or non-achievement of the indicator; yellow means the indicator is present or under development; green means that the conditions for fulfilling the indicator have been met.

The second model is based on the supply chain. It is therefore this model that was applied to the case study on the croton sector. The indicators selected were:

- Incentives: those provided by the government to stimulate development of the sector;
- Added value to the natural resource: all the co-products obtained from the processing;
- Income improvement: the average income indicated by the farmers interviewed and reported in the literature;
- Job creation: at the processing plant and in the business models;
- Gender: the women working not only in the processing plant, but also in the business model;
- Logistics: the infrastructure available for processing the croton fruits and for transport

The qualitative assessment is presented in Table 1. With regard to incentives, current policies in Kenya do not generally support the croton sector. Logistics is coded yellow because the plant in Nanyuki is currently experiencing some problems with its lease, which leaves the company vulnerable. The green indicates where the interviewees indicated a positive effect or condition.

Table 1 Qualitative assessment of selected indicators

Indicator/County	Nanyuki	Nyeri
Policy/incentives		
Added value (co-products)		
Income improvement for farmers		
Job creation (at processing plant)		
Gender (inclusion of women in the business model)		
Logistics		

The case study also shows that the uses for all the co-products mean that EFK is complying with the principles of a circular economy (EMF, 2019) by reusing the cake from the oil extraction and the husks from the fruits. Nonetheless, from a social sustainability point of view, farmers would be providing additional added value if they de-husked the fruits locally where the nuts are collected, and then transported only the nuts. They could also undertake the composting, but this would require a different business model that the company would need to investigate. These activities will provide an added value to the nuts and therefore contribute to improved livelihoods as part of bioeconomy (Ronzon and Mbarek, 2018).

7. Key messages for scaling-up

The interviews with the government representative at Nanyuki Environment (David King'ori 2019), Rodrigo Ciannela (2019; ICRAF 2019) and Cosmas Ochieng (2019) show that they all face similar challenges regarding the scaling-up of activities. First and foremost, there is not enough government support for providing incentives at the national and county levels. In addition, more work is needed to create an enabling environment. The police, for instance, should cease stopping trucks. Third, local investment is difficult, although EFH claims that US investors are making this easier. Finally, climate change-related factors are forcing the team of collectors further into the eastern provinces, meaning that additional transport needs must be considered.

Regardless of the challenges confronting the bioeconomy in East Africa, there is potential that has not yet been properly addressed. The croton case described above demonstrates the potential of the bioeconomy, where the collection of croton nuts results in several value-added products, thereby supporting sustainability and circularity. Specific support should now be developed for agro-processing, and the institutions and civil society actors engaged in complex value-addition activities. This will allow the benefits of the bioeconomy to be expanded, as the CEO of EFK indicated: "As a social entrepreneur I want to see people getting a value from products, and to provide employment to farmers and suppliers" (Interview, Cosmas Ochieng 2019).

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¹ <http://efk.co.ke/>

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