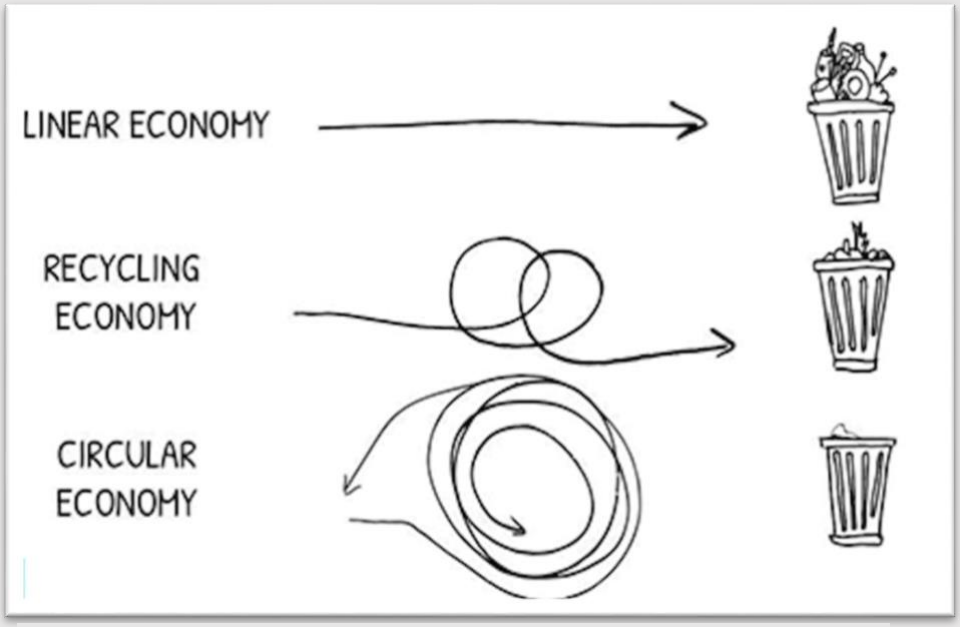
Towards circular food production systems in East Africa

What are the barriers, drivers, and solutions to implement a circular economy in the agricultural sector in East Africa in order to meet the challenges of the Sustainable Developments Goals (SDGs) 2, 12 and 13?



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March 29, 2020

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Abstract

The African continent is under great pressure to solve the increasing need for food security due to an explosive increase in the population combined with additional challenges from climate change. Furthermore, with the current linear system that is focused on 'take-make-dispose', agricultural emissions are even increasing and contributing further to climate change. Taking these concerns seriously, the agricultural sector should be completely re-designed in a way that it will fulfill the demand of food security in a sustainable manner, while it enhances waste valorization to reduce waste accumulation towards sustainable environmental development.

An alternative to the linear system is a circular economy which seeks to close the loop of resources through the establishment of restorative and regenerative systems. The circular economy is a new concept, which acknowledges that there is limited academic research available, especially in its implementation in agriculture in East Africa. Some studies provide six different typologies of determinants towards the circular economy, namely technical, financial/market, institutional/regulatory, organizational, social/cultural, and environmental determinants. However, there is a lack of understanding of how these determinants are relevant and applied in the circular economy of agriculture in East Africa.

Therefore, this research aims to identify and understand the 'barriers, drivers and solutions to implement a circular economy in the agricultural sector in East Africa with the intention to meet the challenges of the Sustainable Developments Goals (SDGs) 2 (food security), 12 (sustainable consumption and production patterns) and 13 (climate change actions)'. This research intends to provide an in-depth understanding of circular economy determinant(s) and solutions that are relevant and apply to agriculture in East Africa.

This research seeks to cover the 'formal' and the 'informal' agriculture sectors in East Africa. Since this research covers two different target groups with significantly different educational backgrounds and business professionalism, the research approach uses mixed data which can be considered as complementary. Therefore, this research applies two different methods including interactive field observation and a formal survey in multiple East African countries. First, an interactive field observation with a guiding questionnaire was conducted in Rwanda mainly focused on the actors of the 'informal' cassava value chain, which includes input suppliers, farmers, collectors, processors and retailers. The interactive field observations sought to determine the implementation status of the circular economy in the 'informal agricultural

sector' in Rwanda. Furthermore, the implementation barriers of circular economy are identified in the field. Secondly, a survey is conducted with 'formal' agricultural circular and non-circular companies in East Africa, which includes medium to large scale input suppliers, farmers, and agro-processors. The survey has the objective to identify which determinants and interventions are relevant to accelerate the transition towards a circular agriculture in three different countries in East Africa, namely Rwanda, Tanzania and Kenya. The analysis of the interactive field observations of the 'informal agricultural' follows a matching-pattern method to identify circular economy principles and barriers, in which a theoretical framework is utilized to map empirical patterns. Furthermore, coding strategies are used the analyze open questions of the questionnaire of the interactive observations, while closed questions are presented in percentages in tables and charts. A similar strategy is used for the survey, although the survey mostly analyzed the data by percentages in tables and charts.

Conclusions

The circular economy concept rests on three principles: design out waste, keep products and materials in use (re-use and recycle), and regenerate natural systems. Research findings have shown that some circular economy practices are already implemented in Rwanda's food production system.

A circular economy in agriculture in East Africa is mostly visibly implemented by using organic waste of compost as fertilizer. In addition, farmers use organic waste residues of processing activities as animal feed. The technique to store, collect and separate different crops and waste materials is applied by the reuse of containers, baskets and equipment by different actors. Recycling practices are applied by using agricultural bags and jerry cans in daily agricultural activities. Input suppliers recycle old papers into paper bags for selling products to consumers. It is rare that respondents surveyed reported the use of renewable resources in their business activities, such as the use of solar lights or the use of waste to generate energy. Consequently, a circular economy in agriculture in Rwanda is mostly focused on the first (design out waste) and second principle (keep products and materials in use) based on the circular economy principles.

About 37.5 percent of all respondents of the 'informal sector' already work together with other actors in the food value chain related to their waste, especially towards organic waste.

Collaborations related to waste are mostly seen by input suppliers and retailers providing waste for free to customers, informal waste collectors and processors selling (organic) waste to farmers and recyclers (e.g. waste of processing activities is sold to farmers), or use of organic waste by actors themselves as compost or as animal feed.

Despite the circular economy practices in place, there is still great potential for further improvements. Improvements in the use of circular economy practices suggested by the actors of the surveys and interviews include the use of compost or human waste as natural fertilizers to increase the yield. Furthermore, actors of the informal sector suggest the potentials of gathering dumped waste of the village or (organic) waste from the farmers together including manure to produce compost. In addition, processors stress that they could process organic waste into animal feed or other respondents stress that they could sell organic waste of their business activities as animal feed.

This research has uncovered that circular economy practices are also applied in the 'formal agricultural sector' in East Africa. It can be concluded of the results that a circular economy in the 'formal sector agricultural sector' in East Africa is implemented at higher level, since 81 percent of the actors work together with other parties related to their waste versus 37.5 percent of the respondents of the 'informal agricultural sector' in Rwanda. In contrast to the 'informal sector' circular economy collaborations in the 'formal sector' are more focused on active waste collection as input of new business activities rather than selling or providing waste for free.

Furthermore, the survey from the 'formal agricultural sector' show that a significant number of actors are not only focused on the utilization of organic waste as compost and animal feed (first principle) and the re-use and recycling of materials (second principle), but also have implemented or plan to implement circular economy practices through regenerative farming. For instance, some actors implement aquaponics, agroforestry or multi-species systems, which is the third circular economy principle. About 81 percent of the respondents have 'some form' of a circular economy business model that applies in-house circularity, work with companies related to residues or the actors' company produce circular innovations. For example, in-house circularity is applied through the use of organic waste as compost or energy for an actor's own company, while other companies produce a circular economy product at commercial scale (e.g.

compost or insect-based animal feed). Despite the existing circular economy practices in place, there is still great potential for further improvements.

The identified barriers of implementing a circular food system in Rwanda are found to be in all of the six typologies of determinants. For instance, there is a great lack of technical support, since only 9 percent of the respondents receive support from government institutions or development agencies to enhance their business activities through training, information or technologies. However, all actors report receiving technical support that is not related to circular economy practices. This can also be explained by the fact that farmers stated their lack of knowledge of organic waste to produce high-quality compost. Furthermore, there is a lack of understanding and awareness about the term "recycling" by the respondents. Many respondents even stressed, that it was their first time that they are approached to discuss waste and recycling topics. This indicates that there is a lack of awareness about the circular economy concept and it's potential. Other implementation barriers include the current limited financial support, since only 37.5 percent of the actors receive financial support which makes it even more challenging to invest in implementing circular economy practices through purchases of technologies and required equipment. There is an acute lack of financial support for farmers and collectors. Furthermore, there are very few existing policy frameworks related to waste management, recycling or renewable resources. In addition, there is an institutional barrier towards the lack of support in interconnecting actors for circular economy practices. Moreover, there are almost no community activities related to organic waste-management, recycling or the use of renewable resources, since only 5 percent of all actors are impacted by communities that are related to a circular economy. The current community activities are mostly focused on gathering plastics, hygiene and construction of the roads. Other relevant implementation barriers include the influence of the seasons in the quantity of organic waste and the need for animal feed during raining seasons. Further, transport barriers play a role since the transport of organic waste or manure can be challenging given limited transportation options.

This study has uncovered that the identified barriers of the implementation of 'formal' circular food systems in East Africa can be found in all of the six typologies of determinants, which is similar to the 'informal sector'. Although, it can be concluded from the research findings that the 'formal agriculture sector' in East Africa has significant more access to technical, financial and institutional support in interconnecting actors for circular economy

practices than the ‘informal sector’. Furthermore, the ‘formal’ sector is more affected by policies and regulations related to circular economy practices than the ‘informal’ sector in Rwanda. Therefore, it could be suggested from the research findings that the ‘informal agricultural sector’ faces higher barriers towards the implementation of circular economy in the agricultural sector than the ‘formal agricultural sector’, which can be explained in part by the differences in the level of education of the various actors.

The most important implementation barriers toward circular ‘formal’ food systems in East Africa include the lack of skilled workers, technical support and knowledge, large capital requirements, and high initial cost to establish a circular economy business model. Other important implementation barriers include the current implementation and enforcement failures related to waste, recycling and renewable energy, which is line with the barrier of the lack of proper waste collection and separation infrastructure/insufficient goods. Furthermore, the respondents also mentioned other barriers such as long administrative procedures to register circular economy innovations for circular food systems and the lack of alternatives for plastics after the introduction of bans for certain types of plastics, which hampers agro-processors in their business activities.

Policy implications

Since the research findings suggest that there is a lack of appropriate policy frameworks and proper interventions related to waste, recycling and renewable resources in the agricultural sector in East Africa, there is a great potential for possible interventions.

Similar to the implementation barriers, solutions are found in all six typologies that are described in the existing literature. It is suggested that the most important technical solutions are in encouraging, incentivizing, and establishing pilot projects in companies; collaboration platforms in order to share knowledge and solutions e.g. through public-private partnerships’; and facilitation of research to develop and improve (new) technologies and business practices through research experiments locations and research budget. Furthermore, training for professionals that work in or around agriculture circular economy concepts and circular food systems and other technical solutions are highly valued. The need for training about value addition to waste and circular economy practices is also stressed by the ‘informal sector’. Other significant important solutions include initiation of industry collaboration platforms (industrial

symbioses programmes) that have the purpose to develop cooperation in an industry where unused or residual resources are used by another; business competitions; and business support schemes to support circular business initiatives. Consequently, there is a need for budgets of the public sector to invest in circular economy activities; to introduce fiscal instruments to encourage circular activities; to improve waste collection infrastructure; and institutional and regulatory framework with common ambition towards a circular economy'.

In conclusion, a holistic approach is needed that combines technical, financial/market, institutional/regulatory, social/cultural solutions, which could be done through and circular economy institution with a national fund for circular economy initiatives. Solutions should include all six typologies of the determinants, since solutions can be found in all typologies. Circular economy is an approach that requires a common ambition of the government, private sector and research institutions. In order to establish a circular food system there is a need for central coordination within the government to achieve a successful transition. Therefore, this study concludes that there is a need for national programs for circular food systems and circular economy-focused institutions.

It is suggested that national programs for circular food systems should implement the following interventions:

- Establish industry and collaboration platforms to share knowledge and solutions. For example, public-private partnerships between universities, knowledge institutions, and government in order to support research questions of the private sector. In addition, a national program should facilitate private sector cooperation where unused or residual resources of one company can be used by another company. These collaborations can either be achieved at (cross) value or at industry level.
- Support research programmes and pilot projects for companies. In East Africa the circular economy is an approach that is not studied in-depth. Research should focus on the design and improvement of technologies and business practices through research experiments. In order to test and improve circular technologies and business practices, there is a need for pilot projects inside companies.
- Financial support for new businesses, industry initiatives and test pilot projects in companies through a special fund. A circular economy focused investment fund could

also encourage companies to develop circular food systems initiatives by organizing business competitions.

- Introduce fiscal instruments (VAT) to encourage companies to develop circular business activities rather than taxes that discourage non-circular economy activities in lieu of waste or other social externalities. This is especially important since not all non-circular economy companies have immediate access to knowledge, technologies and resources to implement circular economy activities.
- Improve and enforce waste collection and separation infrastructure, since there is a lack of separation at the source, during transportation and handling of the waste. An improved waste collection infrastructure results in greater potentials to add value to waste and remove costs for circular business models.

National programs for circular food systems should consider the difference between the 'informal' and 'formal' agricultural sector in East Africa especially since the 'informal' sector face significantly higher barriers to achieve a successful transition.

1. Introduction

Food security is an increasingly important topic on the international agenda. By 2050, the world population will increase to at least 9 billion citizens, and food security will be an enormous challenge (FAO, 2009). The international community took action and formulated the Sustainable Development Goals (SDGs) including SDG 2, which strives to "end hunger, achieve food security and improve nutrition and promote sustainable agriculture" by 2030 (UN, n.d. a, para 1). The FAO reports that the number of undernourished humans worldwide has increased since 2014. In 2017 the number of undernourished people increased by 17 million and reached an estimated number of 820 million people undernourished reflecting negative progress in contrast to SDG 2 (FAO, 2018).

Global food security is further challenged by climate change. Droughts cause water shortages which affect the agricultural sector and the access to food in developing countries. Agriculture is the human activity that is most dependent on climate, which especially effects developing countries that are dependent on agricultural production. On the one hand agriculture is affected by climate change, but on the other hand it also contributes to climate change (Torquebiau, Tissier, Grosclaude, 2016). Consequently, agriculture is responsible for almost 24 percent of the global greenhouse gas emissions (EPA, n.d.). Only over the last fifty years the estimated greenhouse gas data show that emissions of agriculture, forestry and fisheries have almost doubled (FAO, 2014). FAO stress that emissions "could even increase with an additional 30 percent by 2050, without greater efforts to reduce them" (FAO, 2014, para 1). An illustration of the urgency is seen in the emissions from crop and livestock that increase 14 percent every 10 years, mainly due an expansion of the agriculture in developing countries (FAO, 2014).

It is highly likely that the agricultural emissions in developing countries increase further with the growing demand for human and livestock food through an explosive population growth (UN, 2017). This is especially relevant to the African continent, which has the youngest worldwide population (Mathew, 2014) and is expected to have "more than half of the global population growth between now and 2050" (UN, n.d. b, para 3). Currently, African countries are still lagging behind in development and already suffer with high numbers of undernourishment. One of four undernourished people globally is coming from Africa (NEDAP, n.d.), which makes the African continent one of the most vulnerable regions in regards of food security (Torquebiau,

Tissier, Grosclaude, 2016). Furthermore, underdeveloped African countries are more affected by climate change than developed countries, since climate change "often depreciates the wellbeing of the most vulnerable people" (Torquebiau et al., 2016, p. 8). In other words, the current developments and the need for food security in a challenging environment that has affected by climate change creates an enormous and increasing pressure on citizens living in Africa.

1.1 Urgent call for a different approach

These trends, which include the need for increased food security and the ongoing climate change related to agricultural emissions and explosive population growth demand a more sustainable food system to ensure food security. This acknowledges that food systems should be redesigned in a way that it will fulfill the demand of food security in a sustainable manner. This redesign includes relevant regulations, institutions, and financial resources in order to improve the efficiency and resilience of food production systems (Torquebiau et al., 2016)

Currently, developed countries make use of industrialized agriculture systems which increases crop yields to produce large quantities of food. In order to do so, machines are utilized to produce an optimal quantity of food. As a result, that the increased utilization of machinery increases the use of fossil fuels to produce food. Due to industrial farming, the price of food can change through the fluctuation of oil price. According to FAO, "agriculture commodity prices are becoming increasingly correlated with the price of oil" (FAO, 2011, p. 10). The oil price affects agricultural prices indirectly and directly, for instance through the price of fuel and fertilizers (FAO, 2011). Especially developing countries that are net importers of petroleum products are highly affected by the high oil prices, which results in increased costs in agricultural production and thus aggravates the existing food crisis (IMF, 2008).

Industrialized farming is strongly based on a linear economy, which is defined as "a model of resource consumption that follows a take-make-dispose pattern" (World Economic Forum, 2014, p. 13). This means that "companies harvest and extract materials, use them to manufacture a product and sell the product to a consumer, who then discards it when it no longer serves its purpose" (World Economic Forum, 2014, p. 13). This linear model can also be recognized with the utilization of pesticides, chemicals and fertilizers in industrial farming and the correlation between oil and the food price. In addition, current food systems produce a

significant quantity of food waste which results in unnecessary emissions (Sheahan & Barrett, 2017; World Bank Group, 2018). With the growing world population and demand for more food, the current linear model would result in more food waste and loss. Furthermore, agricultural production growth is slower than in the past, and fertility of the soil and the nutritional value of food is decreasing (World Economic Forum, 2014).

In sum, this underlines that industrial agriculture is based on a model that has a lack of solutions for the growing shortage of materials, it will increase pollution and material demand, which makes agriculture based on a linear economy untenable.

1.2 Circular economy

An alternative model is the circular economy, which is "an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models" (Ellen MacArthur Foundation, 2013, p. 7). This acknowledges that the objective should be to create a sustainable system that closes the loop of resources through the establishment of restorative and regenerative systems (Ellen MacArthur Foundation, 2013). This study investigates what the determinants are to implement a circular economy in the agricultural sector specifically in countries in East Africa.

1.3 East Africa an interesting case

This research studies the barriers, drivers and solutions to implement a circular economy in a less industrialized agricultural sector, since a less industrialized agricultural sector may not be as strongly committed to a linear economy. The African continent largely missed the 'Green Revolution' in the 19th century based on the industrialization of agriculture (Frankema, 2013), while agriculture is the major sector for most African countries and economies (NEDAP, n.d.). The agricultural sector in African countries is dominated by family-owned farms dependent mainly on family farm labour, which makes the countries in Africa different from those in other continents (NEDAP, n.d.). This can be seen in the fact that 75 percent of the agricultural production in East Africa is produced by smallholders (Salami, Kamara, Brixiova, 2010).

Agriculture is the backbone of the East African economy and is dominated by smallholders. Agriculture generates an income for 80 percent of East African citizens (East African Community, 2010). The East African agricultural sector is challenged by it its dependency on, unreliable rainfall, the lack of water storage facilities, poor cultivation of land, traditional technologies and farming methods, which results in food insecurity (East African Community, 2010). This could even be more challenging with the negative impacts of climate change, which warrant a different approach towards agriculture (East African Community, 2010). On top of that, the current food system and solid waste management in African countries results in high quantities of food and organic waste (Sheahan & Barrett, 2107; World Bank Group, 2018). An outstanding example for combating these challenges is to implement circular economy principles. Rwanda provides this platform, which will be our case study country with insights informed by actors in Kenya and Tanzania.

1.4 Research question and objective

This study investigates the next research question; *'What are the drivers, barriers, and solutions to implement a circular economy in the agricultural sector in East Africa in order to meet the challenges of the Sustainable Development Goals (SDGs) 2, 12 and 13?*
SDG 2: "End hunger, achieve food security and improved nutrition and promote sustainable agriculture"
SDG 12: "Ensure sustainable consumption and production patterns"
SDG 13: "Take urgent action to combat climate change and its impact" (UN, n.d. a, para 1).

In order to answer the main research question, this thesis answers the next following research questions:

1. What is the essence of the circular economy concept?
2. What is the essence of a circular economy in the agricultural sector?
3. What are the major barriers, drivers and solutions, according to the theory, for the implementation of a circular economy?
4. How is a circular economy implemented in the informal and formal agricultural sector in East Africa?

5. Which drivers and barriers are present in the informal and formal agricultural sector in East Africa?
6. Which solutions are relevant in order to overcome the implementation barriers towards the transition of a circular economy in the agricultural sector in East Africa?

In order to answer the main research question, this thesis first conducts a literature review that is focused on the theoretical aspects of a circular economy. The literature explains the circular economy concept, the belonging principles, barriers, drivers, possible interventions and the meaning of circular economy in the agricultural sector built on available preceding research.

To study the circular economy research areas in the agricultural sector with limited preceding research, a qualitative mixed research method research approach is adopted for the purpose of explorative and theory-building research. It is chosen to apply a mixed research method, since this research has the objective to cover the large 'informal agricultural sector' and the 'formal agricultural sector' in East Africa. Since the 'informal' and 'formal' agricultural sector is a different target group with a significantly different educational background and degree of business professionalism, data from the mixed research approach is considered as complementary. In order to study both target groups, this research applies two different methods to cover the 'informal' and 'formal' agricultural sector.

First, an interactive field observation with a guiding questionnaire was conducted in Rwanda mainly on the cassava value chain. The interactive field observations have the purpose to determine the implementation status of the circular economy in the 'informal' agriculture in Rwanda. Furthermore, the implementation barriers of a circular economy are identified in the field. Secondly, a survey is conducted with agricultural circular and non-circular companies in East Africa. The survey aimed to provide an in-depth understanding of which determinants and interventions accelerate the transition towards a circular food system in East African countries.

A part of the study is focused on Rwanda, since Rwanda is a promising country towards the achievement of a circular economy. Rwanda is one of the three pioneers of the African Circular Economy Alliance, an organization whose objective is to transform the continent into a circular economy, to deliver economic growth, jobs and positive environmental outcomes (African Green Growth Forum, 2018). In addition, Rwanda launched a 'Green Growth and Climate Resilience National Strategy for Climate Change and Low Carbon Development', which

includes short- and long-term actions in policies and projects towards a sustainable future in Rwanda (Republic of Rwanda, 2011).

This research contributes to a regional RUNRES research project of IITA Rwanda (International Institute of Tropical Agriculture), which has the purpose to establish a nutrient loop to improve city and region food system resilience (RUNRES-ETH, n.d.). The RUNRES project has chosen to focus on the cassava staple crop in Rwanda since cassava is an important income resource and staple crop for Rwanda and other African countries (Sygenta Foundation and MINAGRI, 2012; Nweke, n.d). Furthermore, cassava is consumed by households and sold at the local market, which underlines that there is enormous potential to process cassava (Sygenta Foundation and MINAGRI, 2012). Therefore, this study uses the mostly informal cassava value chain to study circular economy aspects for the 'informal sector'.

1.5 Scientific and societal relevance

Societal relevance

A circular economy is for most East African stakeholders a new concept, which is not well known by the society and mainly exist between policy makers, researchers or in theory. Policy makers start to integrate the circular economy in their visions and policies, but implementation partners, like NGOs and embassies, describe circular economy as a difficult concept and have a limited understanding of the value of circular economy principles. This underlines that implementation partners find it hard to translate policies in practical ways to implement circular economy principles. Therefore, this research studies the barriers and solutions to implement a circular economy in the agricultural sector in order to create awareness and to simplify the practical implications of the concept. In addition, the learnings from this research can be scaled to RUNRES focus countries (South-Africa, Congo, Ethiopia and Rwanda), to result in practical implications.

Scientific relevance

In addition, this study is the first academic study that focuses on the determinants to implement a circular economy in the agricultural sector in East Africa in order to meet the challenges of the Sustainable Development Goals (SDGs) 2, 12 and 13. There is limited academic research completed involving the circular economy, especially towards the implementation of a circular

economy in the agricultural sector in this region (Korhonen, Honkasalo, Seppälä, 2018). Moreover, it is also scientifically relevant, that this research studies the determinants to implement a circular economy in a weaker industrialized agriculture sector since a less industrialized agriculture sector is not as strongly committed to a linear economy.

1.6 Reading guide

In order to answer the research question, different sub-questions are answered (paragraph 1.4). The first section of the research provides a theoretical framework to define the concept of the circular economy and its general and specific agricultural drivers and barriers to implement a circular economy in the agricultural sector. Secondly, a research design and methodology discusses the investigation of the barriers and solutions to implement a circular economy in the agricultural sector in order to meet the challenges of SDGs 2, 12 and 13. The next section covers the most important research findings and the last section answers the research question by looking at the sub-questions, followed by a discussion with recommendations.

2. Theoretical framework

The theoretical framework has the objective to answer the following theoretical sub-questions based on preceding research:

1. What is the essence of the circular economy concept?
2. What is the essence of a circular economy in the agricultural sector?
3. What are the major barriers, drivers, and solutions, according to the theory, for the implementation of a circular economy?

The theoretical framework exists of four different parts that each answer one of the three research questions. First of all, the conceptualization of the circular economy is explained, which is followed by an explanation of the essence of a circular economy for the agricultural sector. Following that, different identified barriers and drivers towards the transition of a circular economy are discussed based on preceding research presenting six different typologies. At last, identified government interventions are discussed to overcome the earlier identified barriers per typology. At the end of the chapter, all factors are presented in an overview, which shows, per identified typology, the drivers, barriers and the possible government interventions.

2.1 The essence of the circular economy concept

Since a circular economy is the main concept of this research, it is important to define the concept of a circular economy. As stressed earlier, there is limited academic research covering the practical implications of the circular economy concept (Korhonen, Honkasalo, Seppälä, 2018). Some identified research covers the theoretical conceptualization of the circular economy. However, there is a lack of coherence between different interpretations of circular economy concepts and their principles (Kircherr, Reike and Hekkert, 2017). Kirchherr et al., (2017, p. 1) stress that most of the literature describes a circular economy (CE) as a "combination of the principles reduce, reuse and recycle activities, whereas it is oftentimes not highlighted that CE necessitates a system shift".

According to different studies, the most prominent definition of a circular economy is formulated by the Ellen MacArthur Foundation (Geissdoerfer, Savegt, Bocken, Hulting, 2017;

Kirchherr et al., 2017), which is the founding father of circular economy theory. The Ellen MacArthur Foundation defines a circular economy as (Ellen MacArthur Foundation, 2013, p. 7):

"[CE] an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models."

A circular economy rest on three principals (Ellen MacArthur Foundation, 2019; Ellen MacArthur Foundation, n.d.).

1. *"Design out waste and pollution*: a circular economy reveals and designs out the negative impact of economic activity that causes of damage to human health and natural systems" (Ellen MacArthur Foundation, 2019, p 24). This requires a mindset change that considers waste as input and as a design for new materials and technologies, while biological materials are non-toxic and easily flow back to in the soil by composting or anaerobic digestion (Ellen MacArthur Foundation, n.d.; Ellen MacArthur Foundation, 2015a).
2. *"Keep products and material in use*: a circular economy favors activities that preserve value in the form of energy, labour and materials the value in the form of energy, labour and materials. This means designing for durability, reuse, remanufacturing, and recycling to keep products, components, and materials circulating in the economy" (Ellen MacArthur Foundation, 2019, p. 24).
3. *"Regenerate natural systems*: a circular economy avoids the use of non-renewable resources where possible and preserves or even enhances the renewable ones" (Ellen MacArthur Foundation, 2019, p. 24).

The Ellen MacArthur Foundation (2019) has specified the concept further by the utilization of biological and technical cycles (figure 1). The biological cycles regenerate living systems, like soil, which provide renewable resources for the circular economy (Ellen MacArthur Foundation, n.d.). The biological cycle is a cycle where bio-based materials (such as wood and cotton) are developed to re-enter the biosphere through circular economy practices such as composting (Ellen MacArthur Foundation, 2019; Ellen MacArthur Foundation, n.d.).

In the technical cycle the focus is on recovery and restoration of products and the belonging components and materials. This is done through approaches like reuse, repair, remanufacture or recycling. The technical cycle requires the management of stocks of finite materials and resources (Ellen MacArthur Foundation, 2019; Ellen MacArthur Foundation, n.d.)

The model also makes a distinction between the power of an inner circle, longer circle and cascades (figure 1) (Ellen MacArthur Foundation, 2015a). The circle or cascade refers to the concept how of tighter the circle or cascade, the more valuable the circular strategy (figure 1). For instance, repairing and maintaining a product sustains most of its value. In case that is not possible, individual components can be reused or remanufactured, which increases the value more than only the recycling of materials. A longer maximum circle (the longer cycle), can be accomplished through reusing a product a number of times or through the extension of the life of a product. The cascade refers to the concept of diversify reuse across the whole value chain. An example that is provided by Ellen MacArthur Foundation (2015a) is the reuse of cotton clothing as second-hand clothes, where after the cotton fiber-fill is used in the furniture industry, it is reused in stone wool insulation for construction (Ellen MacArthur Foundation, 2015a).

In sum, a circular economy aims to close the loop of resources through the establishment of restorative and regenerative systems (Ellen MacArthur Foundation, 2013). In contrast to circular economy, “the traditional linear economy uses a ‘take, make, dispose’ economic model that relies on large quantities of cheap and easily accessible materials and energy” (World Economic Forum, 2016, para 5). The linear economy is considered as a not sustainable model reach its limits (World Economic Forum, 2016).

A circular economy requires a different mindset, which applies system-thinking on a broad level. Many elements in the world like businesses, people or plants are part of complex systems that are depending and connected with each other, which can result in different consequences (Ellen MacArthur Foundation, 2015a).

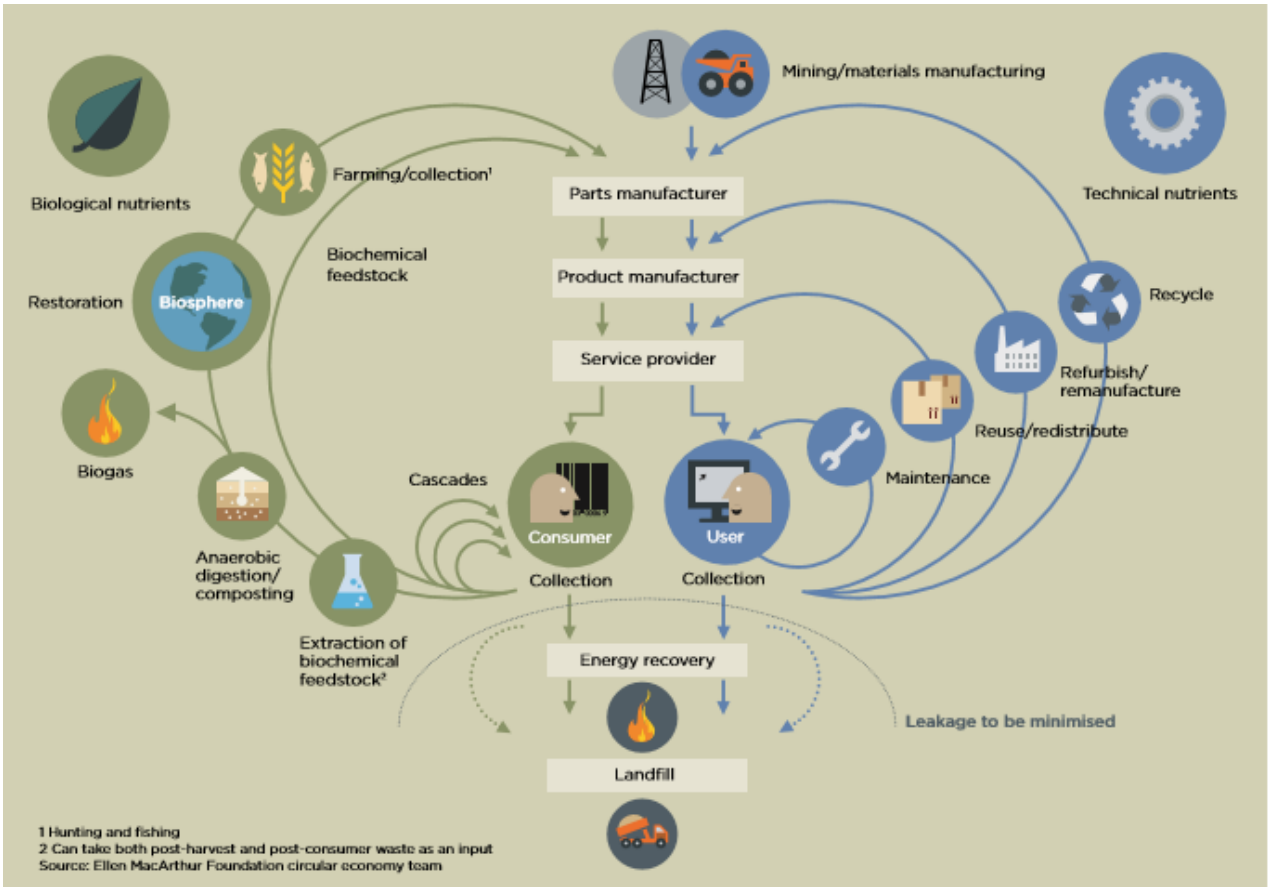

Figure 1. Overview of a circular economy as an industry system. Source: Ellen MacArthur Foundation, 2013, p. 24.

2.2 The essence of the implementation of a circular economy in the agricultural sector

A traditional linear economy is focused on 'take, make and dispose' and is concentrated on substantial quantities of low-priced, simple accessible energy and resources (Ellen MacArthur Foundation, 2015b). For instance, the chickens of a traditional poultry farm in a linear economy are fed with grain that requires inorganic fertilizer and are kept in sheds that require oil, gas and electricity. Only the feed production contributes already 65 percent of the energy (Toop, Ward, Oldfield, Hull, Kirby, Theodorou, 2017). By contrast, a circular economy has the objective to close the cycle of resources. Currently, scholars have different ways to describe the implication of circular economy in the agricultural sector and discuss it at different levels. Therefore, this paragraph discusses the different conceptualization of the circular economy in the agricultural sector (circular agriculture) defined by different scholars to gain a better understanding of the essence of circular agriculture.

Circular food systems

One of the most recent studies about circular agriculture is from Wageningen University (WUR), which describes circular agriculture in a wider context. In the literature the scholars refer to the concept of circular food systems. WUR (n.d.) describes a circular food system as "keep residuals of agricultural biomass and food processing within the food system as renewable resources" (WUR, n.d., p.4). This includes a more efficient use of scarce resources, reduction of wasted biomass and imports, such as inorganic fertilizers (WUR, n.d.).

The Dutch scholars, De Boer and Van Ittersum (2018) provide a scientific framework for circular agricultural production in Europe. This scientific framework has the purpose to create an overall circular food production system approach, which includes circular agriculture as an integral part. It is important to note that the term food system refers to "a complex web of activities involving the production, processing, transport and the consumption of food" (University of Oxford, n.d). However, the term agriculture refers to "the science and art of cultivating the soil, including the allied pursuits of gathering in the crops and rearing livestock, tillage, husbandry, farming" (Harris and Fuller, 2014, p. 104). In other words, a circular approach towards a food system is the overall approach, which is much broader than the focus on a circular agriculture, and includes issues as economics and governance of food production, its sustainability, the effects of food production on the natural environment, the degree of food waste and the impact of food on the health at individual and population level (University of Oxford, n.d.). The concept of WUR (n.d.) to describe circular agriculture as a part of a circular food system is in line with the Ellen MacArthur Foundation (2019) that also stresses a circular economy to encompass the full value chain of producing food for human consumption including "agricultural activities and other means, through handling, transportation, storage, processing, distribution and consumption to organic (including human) waste management and disposal" (Ellen MacArthur Foundation, 2019, p. 7) (figure 2). In order to explain circular food systems further, the Ellen MacArthur Foundation (2019) refers back to the earlier mentioned principles (paragraph 2.1).

According to De Boer and Van Ittersum (2018), a circular food system "implies searching for practices and technology that minimize the input of finite resources (like carbon, nitrogen, phosphorus, water) from the food system, and stimulate the reuse and recycling of inevitable resource losses in a way that adds the highest possible value to food system" (De Boer

and Van Ittersum, 2018, p. 13). The scholars De Boer and Van Ittersum (2018) underline that a circular food system considers plant biomass as the foundation of the circular food production system. This means biomass should primarily be utilized to produce human food. By-products from food production, processing and consumption are either recycled or reused into the food system. The scholars describe that an optimal circular food system utilizes animals to untap inedible biomass for humans into useful food, ecosystem services and manure (figure 2) (De Boer and Van Ittersum, 2018).

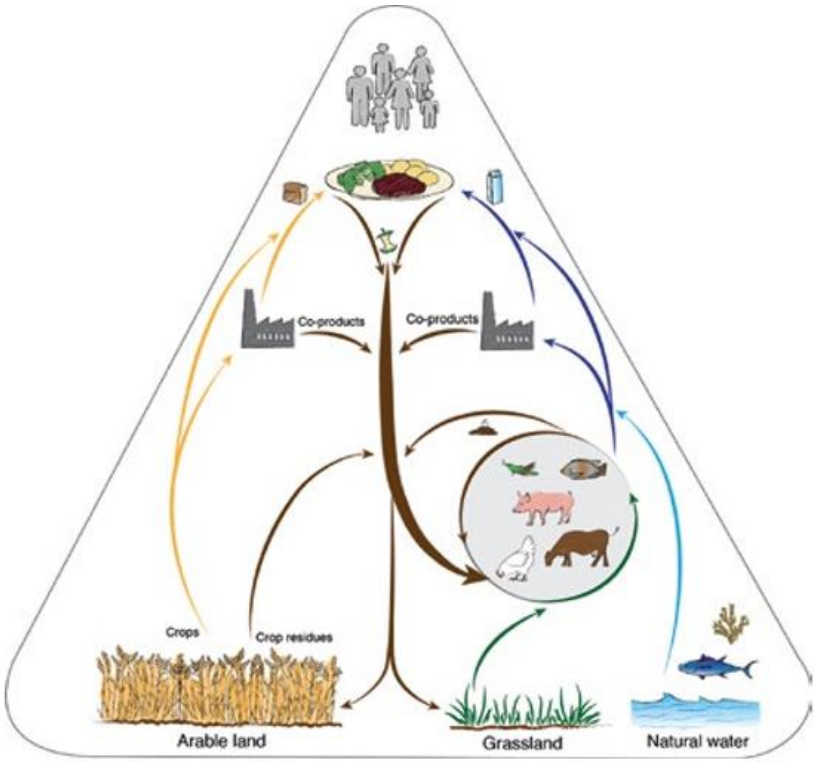

Figure 2. Circular food system. Source: van Zanten, van Ittersum, & De Boer, 2019

Circular agriculture as a system approach

As described earlier, circular agriculture is an integral part of a circular food system (Scholten et al., 2018). Scholten et al., (2018) specified the concept more and stresses that circular agriculture is an integral part of a circular food system within a "biobased" society. Therefore, it requires a system approach to study the whole value chain or food system (Scholten et al., 2018; Ellen MacArthur Foundation, 2019). Consequently, a system approach requires the inclusion of different scales including scope and time. For instance, it is essential to close circular agriculture at local scale. However, for national or global food production system different local cycles need

to be closed and connected (Scholten et al., 2018). Furthermore, a systems approach is not only focused one value chain, but also on cross value chains, industries and other aspects of the food system. Especially since by-products can be used in different ways or are coming from processers, such as food waste or lost from bakeries or restaurants. Furthermore, circular food systems in urban areas require collaboration between different stakeholders, such as private and public sector to establish a circular food system (Ellen MacArthur Foundation, 2019).

2.3 Identification of drivers and barriers in the literature for achieving a circular economy

The transition from a linear towards a circular economy in agriculture is a fundamental change, therefore it is crucial to identify and understand which drivers and barriers exist in the transition towards a circular economy. The implementation of a circular agricultural sector requires a collective approach by many stakeholders, such as farmers, citizens, businesses, scientists and government for optimum ecological principles with modern technology, partnerships, new economy models and social services to overcome barriers (WUR, n.d). Therefore, this section identifies the barriers and drivers to achieve a circular economy and provides an overview of these identified determinants.

General drivers and barriers towards the implementation of a circular economy

The circular economy has received increasing attention from researchers, governments and businesses. There are several studies done on the progress of the implementation of a circular economy. However, relevant academic research about the implications of the circular economy remains largely unexplored (Korhonen, Honkasalo, Seppälä, 2018), especially towards the implementation of a circular economy in the agricultural sector in East Africa.

A paper by de Jesus and Mendonça (2018) provides a state of art overview of several studies that conducted research about the implementation of a circular economy and in order to contribute by analyzing evidence which factors hampers and supports the development of a circular economy. The researchers make a separation between *soft factors*, which are related to regulatory and cultural issues (i.e. social, regulatory or institutional factors) and with *hard factors*, more closely to techno-economic trajectories (table 1).

Table 1. Factors and barriers that hamper the transition towards a circular economy

	Drivers	**Barriers**
Technical and economical	Hard drivers	Hard barriers
Institutional and social factors	Soft drivers	Soft drivers

Source: de Jesus and Mendonça, 2018.

An important conclusion of de Jesus and Mendonça (2018) is that a successful implementation of a circular economy requires not only technical innovations but also large-scale institutional changes in public regulations, social practices, and markets. The study of de Jesus and Mendonça provides an overview of four different typologies of determinants, namely technical, economical/financial, institutional/regulatory and social/cultural determinants (table 2). This paragraph uses the structure of the typologies and the content (table 2) to identify more barriers and drivers in additional relevant literature (table 3 and 4). The other identified typologies are organizational and environmental typologies, which are illustrated in the text below.

Table 2. Overview of the typology and definition of drivers and barriers towards the implementation of a circular economy

		Drivers	**Barriers**
Hard factors	Technical	Availability of technologies that resource optimization, re-manufacturing and re-generation of by products as input to other processes, development of sharing solution with superior consumer experience and convenience	Inappropriate technology, lag between design and diffusion, lack of technical support and training
	Economical/ Financial/ market	Related to demand-side trends (rising resource demand and consequent pressure resource depletion) and supply-side trends (resource cot increases and volatility, leading to incentives towards solution for cost reduction and stability)	Large capital requirements, significant transaction costs, high initial costs, asymmetric information, uncertain return& profit
Soft factors	Institutional/ Regulatory	Associated with increasing environmental legislation, environmental standards and waste management directives	Misaligned incentives, lack of conductive legal system, deficient institutional framework
	Social/cultural	Connected to social awareness, environmental literacy and shifting consumer preferences (e.g. from ownership of assets to services models)	Rigidity of consumer behavior and business routines

Source: de Jesus and Mendonça, 2018.

Technical

De Jesus and Mendonça (2018) identify that the accessibility of technical solutions is a crucial criteria for adaptability, therefore technological challenges are considered as a key barrier in the transition to a circular economy. Technical barriers not only include factors towards existing

technologies, but also lack of sufficiently educated workers and technology gaps. Especially towards the implementation of a circular economy in the agricultural sector, Termeer (2019) and PBL (2018) stress that the path dependency – the idea that choices made in the past circumscribe current and futuristic options – of farmers on their current knowledge and experience is a great barrier to embrace a circular economy. The issue of path dependency is stressed as a possible barrier since farmers have chosen to specialize themselves in certain value chain(s). For instance, it does not have an additional value to follow a training about biological farming with cattle for a farmer that is specialized in pig farming (PBL, 2018).

De Jesus and Mendonça (2018) claim that a successful transition requires a holistic approach, which includes technological innovations as one of the factors to achieve a circular economy. For instance, technical innovations also require other measurements since innovations enter the market slowly, due to investment and market barriers. De Jesus and Mendonça (2018) concluded that there is a holistic innovation needed, which include organization and market aspects as well. A similar conclusion for circular agriculture is made by WUR (n.d.), which stresses that circular agriculture should be a collective approach by farmers, businesses, interested citizens, scientists, and researchers in order to create the optimum combination of ecological principles with modern technology, partnerships, and new economic model and social services.

Market & financial investments

Technological innovations have often limited practical implementation due to economic and market limitations, since existing technologies are frequently accompanied by problematic lock-ins and by path dependencies. Innovations have an uncertain market and require high investments and high transaction costs, such as the finding and negotiation with customers or suppliers, limits new investments (de Jesus & Mendonça, 2018; Ellen MacArthur Foundation, 2015 b). In addition, it is a challenge to launch circular innovations, while non-circular existing technologies have already achieved leading positions in the market and try to hold their incumbent position (Korhonen et al., 2018). Termeer (2019) stresses that farmers depend on materials and technologies, which makes it challenging for farmers to change to alternatives, due to long-term investments in land, technologies and in systems in their companies. The literature also stresses that imperfect or asymmetric information could have a negative impact on the

quality of market decisions (Ellen MacArthur Foundation, 2015 b). In addition, insufficient investments in public goods and infrastructure through the market or the state might be an important barrier, but also insufficient competition/markets that results in lower quantity and prices are not desirable.

Financial barriers related to development and implementation costs, initial costs (also called linear economy lock-ins) could constrain the inclusion of new circular economy business models. These costs can be considered as a challenge for the agriculture sector, since banks or other investors would not have a strong appetite to provide new loans for new investments with a new business model. Small enterprises and countries that face financial challenges would be especially affected by financial barriers to develop and implement innovations (de Jesus & Mendonça, 2018). Furthermore, countries that depend on the export of the rural resources could consider a circular economy as a threat, since a circular economy has the potential to result in cost savings, to release in valuable materials and energy in existing products and to decrease the exposure to market fluctuations (Desmond & Asamba, 2019). Although, countries with ecological economies, economies with a long tradition in recycling and to her circular economy concepts on macro-economy level, may be the most fruitful source to develop a circular economy (Desmond & Asamba, 2019) (Korhonen et al., 2018). Despite the fact that financial and market barriers could hamper the development towards a circular economy, financial and market-driven drivers are still important factors in the transition.

Revenue models

Jonker, Stegeman and Faber (2018) stress that the transition from a linear towards a circular economy requires a different revenue model. For the transition from a linear towards a circular economy, Jonker et al. (2018) developed a five-phase model (loops ladder), in order to break down the transition for businesses in five phases. The first phase, also called '*in house circularity*', the organization ensures the closure of cycles within the scope of the organization itself. In the second phase, also called '*partial chain integration',* the organization is no longer only focused on the internal operations of one organization, but one particular part of the value chain in exists of different organizations where a partial closed cycle emerges. In the third phase '*material mono-flow cycle',* the operations of the companies are developed in such a manner that components from natural sources end up in a closed loop. This is followed by the fourth phase,

'*interdependent mono material cycles*', which is a complex tangle of mono-material cycles and involved parties to cope with various inter-related challenges on long term and short of long-term. At last an 'organizational-economic system' is created, which is a further interweaving of interlocking of complex cycles. This phase requires different manners of collaborations with the involved parties in and around the organization, including the institutional context (Jonker et al., 2018, p. 11-12).

This loops ladder (Jonker et al., 2018) suggests that a circular economy requires collaborations between different establishments (like companies) in an integrated chain, which makes the revenue models dependent and complementary on each other. In other words, residues of one organization could be exploited as a resource for the other party, which results in a reuse of resources. For instance, the use of the waste of coffee grounds to grow mushrooms for consumption. In the chain integration it is important to make a division of expenses and revenues between the organizations. As a result, joint business models can be an organizational challenge (Jonker et al., 2018). This requires a clear division on costs and rewards between the involved parties of the integrated chain. As a result, inter-organizational revenue models can be an organizational challenge, since it requires separate businesses to be interlinked with each other. The Ellen MacArthur Foundation (2015 b) emphasizes that some circular opportunities are not profitable for companies even if other problematic challenges are solved, which is large barrier for businesses.

Organization/planning

In addition, a circular economy revenue model can be an organizational challenge. Jonker et al. (2018) stress that partners need to have joint control and governance over the organization or joint organization. On top of that, it also requires new types of governance that are not only focused on the individual establishment but also include joint organization aspects.

In addition, the participating parties in the integrated chain, have a complex tangle of cycles and the parties need to cope with various interrelated challenges with a variable short or long-term perspective. In other words, there is a distinction between short and long cycles of materials and resources. Some materials are available almost constantly (for instance different packaging materials such as bottles, paper, and paper bags), some materials are available after a

few years (such as tractors, cars, motorcycles, etc.), while other resources (such as bricks in a house or a steel of a vessel) have a far longer lifespan.

Jonker et al. (2018) stress that it is not possible for all materials to be immediately fully circular, while other materials can be circular in a short time. As a result, different life cycles of materials are a barrier towards the development of a circular economy. Consequently, a joint organization, management and planning is an important driver towards the development of a circular system. On top of that, a long-term vision and perspective is essential to accomplish a circular economy, which calls for a full commitment of the partners (Jonker et al., 2018).

Social/cultural

De Jesus and Mendonça (2018) uncovered that trends like the business perception of reputational advantages and social sensitivity to environmental issues, changing customer preferences (from ownership to services business models) are assumed as social determinants towards a circular economy. However, cultural acceptance and consumer desires for circular business models are slow due to inadequate awareness and information and possible available choices.

According to Jonker et al. (2018) it is currently impossible for citizens who are used to an environment that is more economical and thrifty to utilize their products longer. The current consumer economy is focused on new improved products rather than a longer utilization of products or to repair products (also called obsolesce). Obsolesce has the purpose to "accelerate the obsolescence of products with intent of planned replacement" (Jonker et al., 2018, p. 8). The principle of 'obsolescence' has nestled in design and production cycles, in operating systems of organizations, bookkeeping, but also in important indicators, such as Gross Domestic Product (GDP) (Jonker et al., 2018).

In addition to consumer behavior, this research could also look into the relationship of personal or social behavior on a circular economy. Unfortunately, this study was not able to found proper in-depth information about the relationship between social/personal behaviors on a circular economy. It is also stressed in the literature that there is a lack of attention for social and ethical issues in the circular economy concept since it mainly is focused on economic and environmental pillars (Inigo & Blok, 2019). However, the literature does stress that it is important that circular innovations are accepted by the society. A study about house waste recycling in China concluded that social norms and emotions were important determinants of

behavior changes for recycling behavior, while prompts are identified as less important (Dai, Gordon, Ye, Xu, Lin, Robinson, Woodard and Harder, 2014). In the study of Dai et al. (2014), investigated the influence of reminders and information for citizens about house waste recycling through door stepping. Dai et al. (2014) suggest that door stepping leaves people behind with a positive feeling, which encourages the citizens to recycle more.

In addition to emotions, some global citizens are sensitive to shared community norms. Therefore, shared community norms could be utilized by an improved emphasis on collective participation and achievements. For instance, the community identity could be used to establish a caring, responsible or green community (Agrawal & Gibson, 1999; Dai et al, 2014). Especially the role of the communities in the African culture can be emphasized as an important one, since communities are considered as the culture that provides the individual with the raw resources to build a personal life (Agulanna, 2010). Therefore, social pressure and the community itself could be a great driver towards behavior change to the adoption of a circular economy. Since agriculture is the main income for rural communities, social pressure and norms, and communities are highly presented in the East Africa agriculture.

Institutional and regulatory barriers

De Jesus and Mendonça (2018) stress that institutional and regulatory drivers are mostly defined as facilitation factors by the academic world. Despite institutional and regulatory factors have the role to be the driver of change, it is also one of the most important aspects that hampers the transition towards a circular economy. An optimal palette of rules, taxes, educational set-up and infrastructure is essential to support a circular economy, while non-conductive legal systems and misaligned incentives hamper the development towards a circular economy. National and regional governments should play a guiding role in the promotion of institutional frameworks through reform of existing laws, promotion of implications of new environmental technologies, organization of public education and to enact new regulations. Another driver towards circular economy development is the promotion and support of research, education and training to improve awareness and the essential skills. De Jesus and Mendonça (2018) conclude that there is an institutional framework needed with policy implications and policy coherence, which include a strategic roadmap.

A governmental barrier that has been stressed by different studies (Jonker et al., 2018; Termeer, 2019) is the shift between different parliaments that could lead to impacts towards circular economy policies. Therefore, Jonker and Termeer both stress that a long-term plan is needed in order to implement a long-term policy over a stable period that should not be affected by shifts in the government (Jonker et al. 2018; Termeer, 2019). This plan needs to provide a vision and strategy towards a circular economy for two or three government periods despite of the composition and political color of the ruling coalitions. This should also include a large investment in new infrastructure and organization (Jonker et al., 2018).

Ranta, Aarikka-Stenroos, Ritala, and Makinen (2017) stress that the general drivers of circular economy support recycling as the core of circular economy practices, while the support for other circular economy practices are lacking. This underlines that there is only a focus on one of the principles, which is recycling, while there is a lack of institutional support for reduce and reuse efforts. The study concludes that to improve the institutional support for circular economy development there is a need for institutional support to reduce the produced products. Following that, this also requires institutional support to increase the reuse of resources and materials (Ranta et al., 2017). In line with Ranta et al. (2017) the Ellen MacArthur Foundation (2015 b) stress inadequate defined legal framework and poorly defined targets and objectives to an industry can form an important barrier towards the transition. The failures in implementation and enforcements that are related to regulations and the unintended consequences of existing regulations can hamper circular practices. For instance, existing food safety policies prohibit the utilization of animal commodities as feedstock in Denmark (Ellen MacArthur Foundation, 2015 b).

Instead of discussing all the different policy drivers that could help to overcome the earlier defined barriers, the next section underlines important policy interventions (which services as drivers) in order to overcome the earlier identified barriers that includes technological, financial/market, economic, environmental, and institutional/regulatory barriers. The government has a role to overcome barriers and path dependency that hinders the transition, therefore it deserves special intention how policy makers can accelerate the transition. Before this can be discussed, it is important to summarize the identified barriers and drivers. Therefore, this paper first provides an overview of the earlier identified barriers and drivers (table 3),

afterwards it discusses the policy interventions that can be implemented by policy makers and governments to overcome the barriers.

Environmental barriers and drivers

As discussed earlier, current government policies are mainly focused on recycling, while there is a lack of support for other circular economy principles including reuse and reduction (Ranta et al., 2017). Recycling reduces waste that needs to be buried or burned and it is a useful way to reduce sourcing materials from the environment. However, it is important to note that not all materials can be recycled since material is downgraded after a number of reprocessing cycles, which results in lost quality and quantity. In addition, energy costs in recycling might be considered, especially since not all energy comes from renewable resources. Recycling also involves environmental and health risks, for example the use of chemicals. Especially for smaller waste, the environmental costs of transportation to plants for recycling can outweigh the benefits of recycling. Therefore, recycling is the least environmentally friendly solution of all the three circular economy principles (Inigo and Blok, 2019). Ranta et al. (2017) stress earlier that a circular economy also requires institutional support for the principles reduce and reuse.

Table 3. Overview of the identified barriers and drivers towards the implementation of a circular economy.

	Barriers	**Drivers**
Technical	Inappropriate technologies Lack between design and diffusion Lack of skilled workers, technical support, training and knowledge Path dependency in specialized knowledge-, technological skills and large investments in specialized technologies	Availability of technological solutions Research, capacity building through training to improve knowledge and skills Re-manufacturing and re-generation of by products as input to other processes, development of sharing solution for superior consumer experience and convenience
Financial/ market	Large capital requirements Significant transaction costs High initial costs Asymmetric information Uncertain market New business models that are not proven hamper investments (planned obsolescence) Insufficient public goods/infrastructure Insufficient competition/markets Path dependency on previous long-term investments The economy is depending on the export of natural resources Countries or SME's with financial challenges Circular models are depending on other business in one integrated value chain Circular business models are not profitable	Related to demand-side trends (rising resource demand and consequent pressure resource depletion) and supply-side trends (resource cot increases and volatility, leading to incentives towards solution for cost reduction and stability) Ecological economies Joint organization and alternative revenue models for circular business models
Institutional/ Regulatory*	Misaligned incentives Inadequate defined legal frameworks Poorly defined objectives and targets Implementation & enforcement failures Unintended consequences of existing regulations Changing governments with changing policies Lack of government investment capital/willing Insufficient public goods/infrastructure	Realigned incentives Clear direction & objectives Increasing environmental legislation environmental standards and waste management directives. Strategic roadmap Policy coherence between policies to support a circular economy Long term government plan that invest in new infrastructures and organization independent from government changes Regulations to encourage circular economy activities/discourage non-circular economy activities
Organization/ planning	Different life cycles of products (long- and short term)	(Long term) planning and joint organization between partners in an integrated value chain that makes a distinction between long- and short life cycles of products Organization of an inclusive holistic approach of different stakeholders (farmers, businesses, interested citizen, researchers and government)
Social/ cultural	Rigidity and path dependency of consumer behavior due business routines and environmental literacy Planned obsolescence	Awareness creation about circular economy and possible available choices, Shifting consumer preferences (e.g. from ownership of assets to services models Social norms and communities Emotions
Environment	Recycling as a dominant circular economy discourse especially at practical levels	Focus on the other CE principals (reduce and reuse) in regulations and in businesses

*****the policy interventions that serves as 'drivers' to overcome the barriers are discussed in-depth in the next paragraph
Source: author's summery and table 2 as start input.

2.4 The transition of linear economy towards a circular economy

The government has an important role to play in overcoming the barriers towards the transition of circular economy in the agricultural sector, which are presented in paragraph 2.3 (table 3). This paragraph discusses the specific government interventions that can be implemented to accelerate the transition towards a circular economy per typology.

Technical barriers

As described earlier, a circular economy is a new concept that is not widely known, especially the essence of a circular economy model is unclear for businesses, industries, cities and nations in a short term and for the next coming years. Therefore, it is important to have more knowledge and a better understanding, in particular towards decision making in policies and in businesses. In order to do so, it is important to change educational systems that teach children and students, and to involve academic research. Research could help to develop and improve (new) business practices and technologies at system level. Furthermore, changes in the educational curricula and the manners of teaching could train graduates and school leavers for the next generation of creative problem solvers. The changes in the curriculum could include circular economy principles and system thinking. At primary and secondary level this could be accomplished through a curricula review, and to focus on system thinking and creative education. The general education system could act to the needs of circular companies to educate graduates and school leavers for circular practices at system level (Ellen MacArthur Foundation, 2015 b). The government could help to establish training for professionals that work in food systems about circular economy and circular agriculture practices (WUR, n.d.).

Besides changes in educational systems, academic research could help to develop and improve new technologies and business practices at the system level (Ellen MacArthur Foundation, 2015 b; WUR, n.d). Termeer (2019) emphasis that the government could facilitate research with the possibility to set up experiments, to facilitate experiment locations (testing sites) and to connect researchers with a research budget. These testing sites are also a place for inspiration and for the development of new knowledge for students and researchers (WUR, n.d.). On top of research, there is also a need for cooperation in order to establish a circular economy, which can be supported by policy. This can be done in the form of collaboration platforms in

order to share and develop knowledge and (technical) solutions. There are different kinds of collaboration platforms, such as industrial symbiosis, voluntary industry initiatives, public agreements, and research and development clusters. A good example is the public-partnerships that could establish cooperation between universities, knowledge institutions and the government in order to support research questions of companies support them with decision making and knowledge building (Ellen MacArthur Foundation, 2015 b). The importance of collaboration platforms for circular agriculture is also stressed by Termeer (2019). Since the knowledge by companies about the circular economy concept is limited, it is suggested that the knowledge by companies can be further extended through demonstration of best practices and by information campaigns (Termeer, 2019; Ellen MacArthur Foundation, 2015 b). The government can set up pilot projects to demonstrate the potential of circular economy activities to companies, while information campaigns can be used to educate important stakeholders. In Denmark for example, farmers are informed by officials about agricultural plastic waste as part of inspection procedures (Ellen MacArthur Foundation, 2015 b).

Financial and market barriers

As discussed in the previous paragraph, businesses can face economic constrains, such as the lack of access to financial resources, technology and some cases of market failures. Policy interventions in the form of financial support, such as subsidies, financial guarantees and capital injections can help companies to overcome financial barriers (Ellen MacArthur Foundation, 2015 b). Termeer (2019) stresses that it is important that the government facilitate financial resources, such as subsidies for agriculture partners, in order to build trust for the government ambitions and objectives for circular businesses. There should be a special focus on small and medium enterprises (SMEs), which most likely have limited capability, internal and financial capacity to take advantage of new potentials (Ellen MacArthur Foundation, 2015 b). Similar to the technical barriers, collaboration platforms can have an important role to overcome financial and market barriers. Businesses that search for business partners for circular innovations can benefit from industry collaboration platforms, especially for companies that have a lack of information or are affected by high transaction costs. These industrial symbiosis programmes include examples such as in France, where the local authorities are directly initiating cooperation around different textiles streams in order to support modernization in recycled textiles. In other words, the

industry works together to develop cooperation in an industry where unused or residual resources of one company are utilized by another company (NCPC, n.d.). Furthermore, voluntary industry initiatives can function in cases where circular innovations require modernization along the value chain (The Ellen MacArthur Foundation, 2015 b). Voluntary environmental industry initiatives "are private/public efforts to enhance corporate environmental performance beyond the existing legal requirements" (Paton, 2000, p. 328). Paton stresses that voluntary initiatives can become an important factor in the combination of public policies and approaches to manage the industrial impact on the environment. Although, the efficiency of voluntary initiatives that are not legally binding might be uncertain compared to legal binding policy instruments.

Furthermore, research and development collaborations can be very effective, in case there is a need for cost-effective technology for a circular economy opportunity. On top of that, sector working groups could be established with the objective to identify circular potentials for companies and their consumers. Industry associations could investigate circular economy business potentials and share knowledge about these potentials in their industry. Moreover, the associations could explore collaboration possibilities on issues such as material specifications and recycling systems. Governments can have a facilitating role to support the industry associations (Ellen MacArthur Foundation, 2015 b). Furthermore, the government can initiate pilot projects to demonstrate the potential of circular innovations with the intention to convince companies about the circular economy potentials (Ellen MacArthur Foundation, 2015 b). In addition, Termeer (2019), stresses that the government can organize business competitions with supportive awards in order to attract positive attention to circular innovations in the agricultural sector.

Institutional and regulatory barriers

As described earlier, poor defined legal frameworks and objectives, misaligned incentives, implementation & enforcement failures and unanticipated outcomes are one of the important implementation barriers for the development of a circular economy. Since the government has a guiding role to establish the right institutional and regulatory framework, it is important to discuss what the government can do towards their own institutional and regulatory framework in order to accelerate the transition to circular agriculture.

Ellen MacArthur Foundation (2015 b) and Termeer (2019) stresses that it is important to include stakeholder groups**,** such as farmers, businesses, interested citizens, environmental organizations, researchers, and a wide range of government officials and academics as soon as possible in order to align ambitions and focus with the stakeholders on the starting point. Since the circular economy is a new concept to most stakeholders, it is important to have a special focus on businesses as their important role as practical implementers of the concept before the government can define and establish a policy framework that includes interventions (Ellen MacArthur Foundation, 2015).

The Ellen MacArthur Foundation (2015, p. 39) identified three important steps to help to establish a circular economy policy framework that is aligned with stakeholders, which include "(1) align on the starting point, ambition and focus, (2) assess sector opportunities and (3) analyze national implications" (figure 4). All steps need the involvement of the stakeholders as soon as possible in order to define an adequate policy framework that is aligned with stakeholders to establish a circular economy. The policy framework should include interventions that help to overcome institutional and regulatory barriers from technical, financial/market, organization/planning, environmental, sector specific and social aspects to achieve a circular economy.

Figure 4. Three key steps of the transition towards a circular economy. Source: Adapted from Ellen MacArthur Foundation, 2015 b, p. 40

Regulatory policy interventions can help to overcome barriers towards circular business opportunities. In some cases, existing regulations can hamper circular economy business activities due to an inappropriate legal framework, which requires the creation or adaption of regulations. The Ellen MacArthur Foundation (2015 b) stresses the importance of the regulations that are linked with trade, product, waste, industry, competition, trade and consumer behavior. Regulations can be used in two different ways, it can either discourage non-circular activities or encourage circular activities. For instance, African countries are leading the world in plastic bag regulations and bans (Livni, 2019), while China has a regulation that stimulates to give food waste as animal feed under highly sanitary conditions (Ellen MacArthur Foundation, 2015 b).

Similarly, as regulatory frameworks, the government can apply fiscal instruments in two different ways, they can either discourage non-circular activities or can support circular economy opportunities with instruments. For instance, China reduced or removed VAT on products that are generated from recycled components, while Denmark is pricing in more of the negative externalities of waste management through fiscal interventions such as the incrementally increase of taxes on landfilled or incinerated waste (Ellen MacArthur Foundation b, 2015). In addition, different studies suggest reforming taxation from labour to natural resources and pollution for an inclusive circular economy (Ellen MacArthur Foundation, 2015 b; Ex'tax, n.d.). This addresses that instead of taxing labour, scarce natural resources are taxed. This reform encourages to create more employment and services, while it discourages overexploitation of natural resources.

In order to inform stakeholders about the policies and regulations, the government could establish a national portal for circular economy business models in agriculture that serves as a national counter for finding solutions towards difficulties in regulations of circular economy practices. On top of that, the portal could also be utilized to inform the private sector about financial instruments for the financial support of innovations and investments (WUR, n.d.).

Strategic roadmap for policy coherence

In order to create a strategic roadmap with a coherent policy framework, policy interventions can be prioritized in cohort policy packages in a logical order. The prioritization of policy options can be done through policy impact and cost assessment to identify administrative-, transaction- and wider economic costs. In addition, the potential of the circular innovations can also play a key role in the assessment and in the sequencing of the impact of various policy options. The Ellen MacArthur Foundation (2015 b) provides a framework that helps to sequence the different policy options on short, medium, and long term (figure 5). The authors stress a couple of general principles that could support the sequencing of policy option that includes; (a) start with the quick wins could help to achieve long term policy interventions, (b) consider the policy options that could serve as the foundation for other options, (c) the policy design and the policymaking process need sufficient flexibility policy in order to re-steer in case it is required, (d) sufficient time and effort should be dedicated to track the implementation progress of policy interventions

to make sure that objectives are achieved (monitor and evaluation) (Ellen MacArthur Foundation, 2015 b; Termeer, 2019).

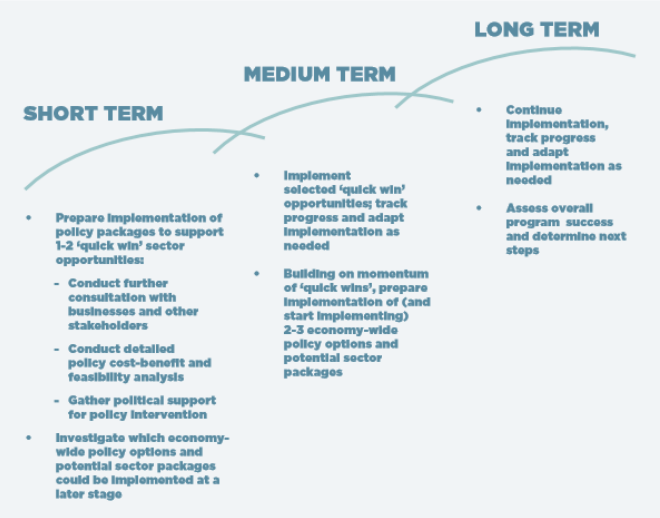

Figure 5. An example of a roadmap for short, medium- and long-term policy intervention. Source: Ellen MacArthur Foundation, 2015 b, p. 85

Small wins

Termeer (2019) stresses the importance of the earlier described principle of quick wins of the Ellen MacArthur Foundation (2015 b) by referring to an in-depth concept of small wins for circular agriculture. As stressed by Termeer (2019) small wins are small and penetrating changes with concrete and practical results that contribute to a common ambition or system change. Small wins are practical matters, such as a policy instrument, a technical innovation, a circular business model or cooperation within a value chain. Small wins are easier to implement, since they are small steps that encourage less resistance, less competition, do not need to wait for required information or processes and develop spontaneous through stakeholders. In addition, incremental steps (small wins) are more time-efficient than large scale changes, since large steps encourage more resistance from political organizations with conflicting needs and values (Lindblom, 1979). This approach could help to build another way of farming in East Africa in steps, especially since the agriculture depends on traditional methods with limited resources and knowledge. Therefore, small steps (small wins) can be considered as stepping stones for a transition towards circular agriculture, since it contributes to a common ambition or system change.

Small wins are by itself not a transition or a system change, however small wins can become a system change or transition by distribution (scaling up of the innovations to apply it at different locations), extension (the innovations is applied at different areas and problems) and deeper penetration (make the innovation more radical). It is difficult to develop a strategy for small wins in advance since small wins can develop spontaneously. However, it is possible to formulate ambitions, recognize and initiate small wins, to establish and activate supporting mechanisms to overcome barriers.

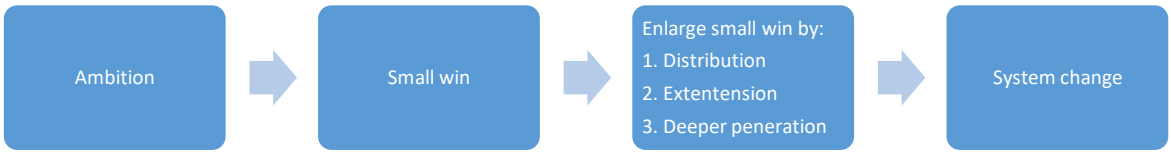

Figure 5. The transition of circular economy from an ambition to a system change. Source: adapted from Termeer, 2019, p. 6.

Public procurement and infrastructure

In case circular economy opportunities are hampered by an inadequate public infrastructure, the budgets of the public sector can facilitate investments to empower circular economy activities. In addition, the government authorities can also help to open access to share their own resources, such as buildings which can be utilized by organizations or individuals (Ellen MacArthur Foundation, 2015 b). The government could initiate to establish a better waste and recycling infrastructure. Especially in East African countries, these structures not well developed, for example in Tanzania there are no government initiatives in respect of recycling practices (Schoot Uiterkamp, Azadi, & Ho, 2011). This is especially needed due to the increase of waste generation relative to continued population growth.

Organizational and planning barriers

It is stressed earlier that revenue models can be an organizational challenge for circular business models that depends on other partners in the value chain, especially since this requires a joint revenue model and organization. This calls for new types of governance that are not only focused on the individual establishment but also towards the joint organization of businesses with common long-term vision (Jonker et al., 2018).

One way to establish cooperation between businesses are industry collaboration platforms. These industrial symbiosis programmes include examples such as in France where the local government directly initiates cooperation around textiles flows in order to support industry

innovations in recycled textiles. In other words, the industry works together to develop cooperation in an industry where unused or residual resources of one company are utilized by another company (NCPC, n.d.). The collaboration can be organized by an association or institution with government support, for instance the Circular Economy Institute in France or the Chinese Circular Economy Association in order to establish an integrated value chain (Ellen MacArthur Foundation, 2015 b). The French Circular Economy Institute took the initiative to generate synergies between businesses in ten different initiatives with the support of the French environment and energy management agency and the Ministry of Environment (Gnidehoue, 2017).

Social cultural barriers

Since a circular economy is largely a new concept and not well known by most citizens in East Africa, there are policy interventions needed that have the objective to increase information and awareness. These interventions should have the purpose to change institutionalized behavior patterns and ways of thinking that are established over a long time. An important tool is the awareness campaigns to inform the public, such as a food waste prevention campaign (Ellen MacArthur Foundation, 2015). Since communities have a great role in the African culture and citizens are sensitive for shared community roles (Agrawal and Gibson, 1999; Dai et al, 2014; Agulanna, 2010) awareness campaigns could be done through the community.

The Ellen MacArthur Foundation (2015 b) also stresses that the consumers could receive information through product labelling about details such as emissions related to the product (Ellen MacArthur Foundation, 2015 b). At the same time, it is questionable how much impact product labels can have in African countries with consumers with less economic resources based on the large informal economy.

Environmental barriers

One of the greatest barriers towards the transition of a circular economy is the dominant institutional discourse towards one circular economy principle, which is recycling. Similar to the institutional and regulatory barriers, this requires realigned incentives with a common ambition towards all three circular economy principles.

2.5 Summary

This paper studies the barriers, drivers and the solutions to implement a circular economy in the agricultural sector in East Africa. From the beginning it is stressed that the circular economy is a new concept and that the literature about the circular economy concept and the related drivers, barriers and solutions are limited. Therefore, it was important to explain the circular economy concept and the essence for the agricultural sector, which is the core of this study. The transition towards a circular economy is a fundamental change, as a result that it is important to identify the barriers, drivers and the (government) interventions towards the circular economy (table 4). In the literature there are six different typologies identified towards a transition from a linear to circular economy, which are technical, financial/market, institutional/regulatory, organizational, social/cultural and environmental factors. All these typologies can be either a driver or barrier (determinants) towards the transition to a circular economy (figure 6). It is important to note that table 2 (de Jesus and Mendonça, 2018) is used as a start input for table three and four.

Although the studies provide the relevance of these determinants, there is limited understanding of how these factors are relevant and apply to the circular agricultural sector in East Africa. Especially since the studies provide general drivers, barriers and solutions that are not applied to the East African context in the agricultural sector. Given the importance of determinants towards a transition to a circular economy in the agriculture sector, this study argues that there is a significant academic research gap regarding the barriers, drivers and solutions in the agricultural sector in East Africa. Therefore, it is important to understand how these factors apply in the agricultural sector in East Africa and which other determinants are relevant to accelerate the transition towards circular agriculture in East Africa.

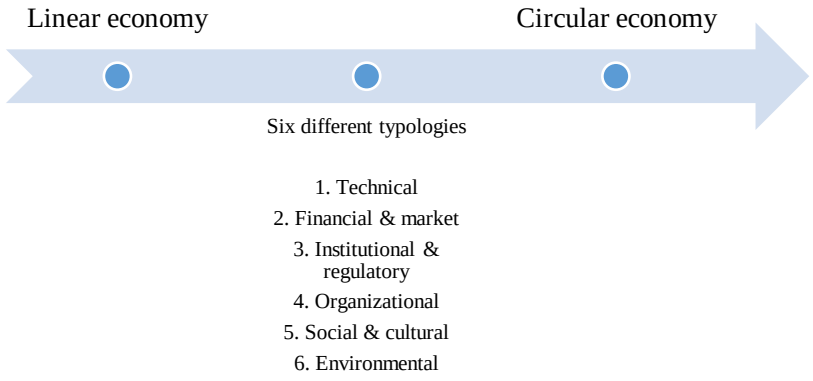

Figure 6. Overview of six different typologies of drivers/barriers towards the transition to circular economy. Source: Author's summary

Table 4. Overview of the identified determinants and interventions towards the transition of CE. Source: author's summary and table 2.

	Barriers	**Drivers**	**Government interventions**
Technical	Inappropriate technologies Lack of skilled workers, technical support, training and knowledge Path dependency in specialized knowledge-, technological skills and large investments in specialized technologies	Availability of technological solutions Research, capacity building through training to improve knowledge and skills Re-generation and re-manufacturing of by-products as input for other business processes, development of sharing solution with superior consumer experience	Change educational systems Training for professionals that are working in/related to agriculture about circular economy & practices Facilitate research to develop & improve (new) technologies and business practices through research experiments locations & research budgets Collaboration platforms: especially public-private partnerships with research institutions/research & development programmes Demonstrate best practices Establish pilot projects Information campaign for companies
Financial/ market	Large capital requirements Significant transaction costs High initial costs Asymmetric information Uncertain market New business models that are not proven hamper investments (planned obsolescence) Insufficient public goods/infrastructure Insufficient competition/markets Path dependency on previous long-term investments The economy is depending on export of natural resources Countries/SME's with financial challenges Circular models are depending on other business in one integrated value chain Circular business models are not profitable	Related to demand-side trends (rising resource demand and consequent pressure resource depletion) and supply-side trends (resource cot increases and volatility, leading to incentives towards solution for cost reduction and stability) Ecological economies Joint organization and alternative revenue models for circular business models	Business support schemes (like grants, subsidies, financial guarantees and capital injections*)* *Regulations to encourage circular business activities/discourage non-circular activities* *Fiscal instruments that encourage circular business activities/ discourage non-circular business activities* Industry collaboration platforms Voluntary industry initiatives Sector-working groups Business competitions with rewards to attract CE businesses
Institutional/ Regulatory*	Misaligned incentives Inadequate defined legal frameworks Poorly defined targets and objectives Implementation & enforcement failures Unintended consequences of existing regulations Changing governments with changing policies Lack of government investment capital/willing Insufficient public goods/infrastructure	Realigned incentives Clear direction & objectives Increase environmental legislation standards and waste management directives. Strategic roadmap Policy coherence between policies to support a circular economy Long term government plan that invest in new infrastructures and organization independent from government changes Regulations to encourage circular economy activities/discourage non-circular economy activities	Align CE ambitions and policies with stakeholders from the beginning Regulations to encourage circular business activities/discourage non-circular activities Fiscal instruments that encourage circular business activities/ discourage non-circular business activities National portal to inform stakeholders about circular economy regulations, policies and financial instruments Shift taxes from labour to natural resources and pollution Strategic roadmap with coherent policy framework Initiate/encourage small wins The budgets of the public sector invest in CE activities Establishing a waste & recycling infrastructure
Organization/ planning	Different life cycles of products (long- and short term)	(Long term) planning and joint organization between partners in an integrated value chain that makes a distinction between long- and short life cycles of products Organization of an inclusive holistic approach of different stakeholders (farmers, businesses, interested citizen, researchers & government)	Industry collaboration platforms
Social/ cultural	Rigidity and path dependency of consumer behavior due business routines and environmental literacy Planned obsolescence	Awareness creation about CE and possible available choices, shifting consumer preferences (e.g. services models instead of ownership) Social norms and communities, emotions	Awareness campaigns to the public and communities
Environment	Recycling as a dominant circular economy discourse especially at practical levels	Focus on the other CE principals (reduce and reuse) in regulations and in businesses	Institutional- and regulatory framework with a common ambition towards CE that includes all principles.

3.Research methodology

This study aims to identify and understand the drivers, barriers and solutions to implement a circular economy in the agricultural sector in East Africa with the intention to meet the challenges of the Sustainable Developments Goals (SDGs) 2, 12 and 13.

In order to answer the main research question, this research answers three empirical sub-questions:

1. How is a circular economy implemented in the informal and formal agricultural sector in East Africa?
2. Which drivers and barriers are present in the informal and formal agricultural sector in East Africa?
3. Which solutions are relevant in order to overcome the implementation barriers towards the transition of a circular economy in the agricultural sector in East Africa?

This chapter discusses how these empirical questions are answered through the data collection and analysis. The first section (paragraph 3.1) discusses how data is collected for the 'informal agricultural' sector through a cassava value chain study in Rwanda and for the 'formal' agricultural sector in East Africa. The second section (paragraph 3.2) examines how the data is analyzed followed by a review about the validity and reliability of the research design and implementation (paragraph 3.3).

By analyzing the main research questions, this study hopes to provide an in-depth understanding of how the identified barriers, drivers and solutions apply in the agricultural sector and which other factors are relevant in order to accelerate the transition towards circular agriculture in East Africa.

3.1 Data collection

To study the circular economy research areas in the agricultural sector with little preceding research, a qualitative mixed research method approach is adopted for the purpose of explorative and theory-building research. This study applies a mixed research method, since this research has the objective to cover the large 'informal agricultural sector' and the 'formal agricultural sector' in East Africa. A mixed research method includes studies that use at least two kinds of data or

two ways of data collection (Small, 2011). Since the 'informal' and 'formal' agricultural sector are different target groups with a significantly different educational background and business professionalism, the data of the mixed research approach is considered as complementary. This is further discussed in the text below.

In order to study both target groups, this research applies two different methods to cover the 'informal' and 'formal' agricultural sector (figure 7). First, an interactive field observation with a guiding questionnaire is conducted in Rwanda mainly on the cassava value chain. The interactive field observations have the purpose to determine the implementation status of circular agriculture in the field in Rwanda. Furthermore, the implementation barriers of a circular economy are identified in the field. Secondly, a survey is conducted with agricultural circular and non-circular companies in East Africa. The survey aimed to provide an in-depth understanding of which determinants and interventions accelerate the transition towards a circular agriculture in East Africa. The surveys are conducted in and outside Rwanda (East Africa), since the circular economy cases in agriculture are very limited in Rwanda.

It is important to note that both ways data of collection are targeting a different target group. The respondents of the 'formal' agricultural sector through East Africa have a university background and are sometimes even 'expats'. However, the current agricultural sector in Rwanda is mostly informal and dominated by smallholders, which underlines that the majority of the respondents have completed primary or secondary schooling at local standards. Although, the questionnaire of the survey contains some similar questions to determine the status of a circular economy, this research has the objective to collect complementary data about two different target groups. Therefore, the questionnaire of the survey provides additional questions about possible (business) barriers and government interventions to implement a circular economy business model. The questions about business barriers and interventions are not included in the interviews of the 'informal' agricultural sector, since both groups will not have the same understanding and insights about (business) barriers and interventions as the respondents of formal companies in East Africa. The different ways of data collection cover together the informal and formal agricultural sector (figure 7).

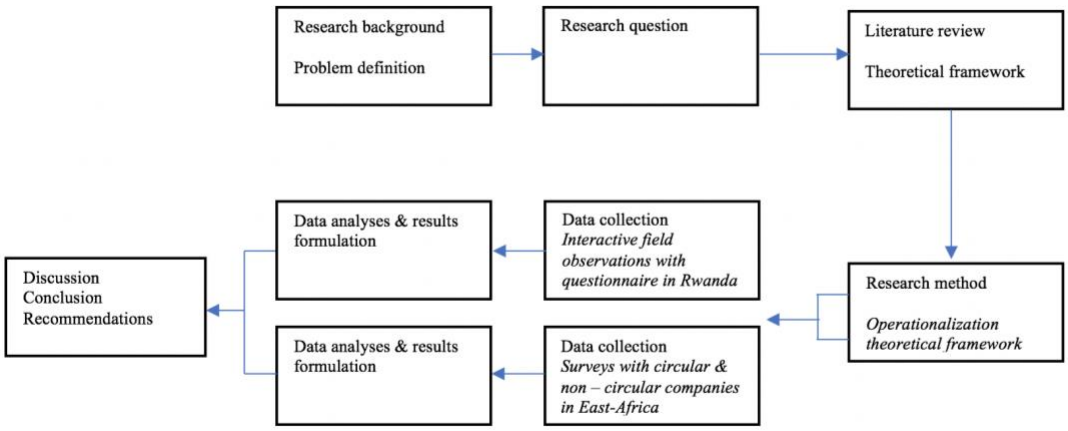

Figure 7. Overview of the research design. Source: author

3.1.1 Interactive field observations

As stressed earlier, the circular economy is a new concept, which acknowledges that there is limited academic research available, particularly towards the implementation status of a circular economy in the agricultural sector in East Africa. Therefore, it is first important to determine the implementation status of a circular economy in the 'informal' agricultural sector in Rwanda, especially since there is no information available about the current implementation status in Rwanda. In order to do so, a participating observation is done, which stresses that the identity of the researcher is known by the persons that are observed and interviewed with a questionnaire. In East African communities a new person is noticed and knowns a strong interactive and hospitality culture, which means that non-interactive observation without interaction with the research units is impossible, particularly in the rural areas of Rwanda. Since the observations are already interactive and the purpose of the interactive observations is to create an in-depth understanding of circular agriculture, the researcher used interactive observations to interview stakeholders with a questionnaire to form a better in-depth understanding of the implementation of the circular economy in the field. This acknowledges that the observations are used to confirm the findings of the questionnaire, especially towards questions that are based on circular economy principles.

Observations based on circular economy principles

The principles of the circular economy (paragraph 3.1) and the biological cycle of circular economy concept (figure 1) are used to observe the current implementation status of a circular economy in the cassava value chain in Rwanda. For each principle, an indicator is identified based on the explanation of the circular economy principles (paragraph 2.1). Based on the indicators and the principles, observation questions are derived that help the researcher to create an observation scheme (attachment 1) and to focus on circular economy principles during the observations in the field (table 5). For instance, empty oil jerry cans that are recycled for the transport of water from the water tab to the farm can be identified as the principle 'keep products and materials in use', following the indicator of table 5 for recycling with the purpose to irrigate the farm. In regards of principle two, it is important to note that the term reuse refers to "products or components that are not waste are used again for the same purpose" (Eurostat, 2019, para 1), while the term recycling refers to a "recovery operation whereby waste materials are processed in materials, products or substances either for original or other purposes" (Eurostat, 2014, para 1). The observations are not only used to identify the current status of a circular economy in agriculture in Rwanda, but also to identify additional barriers and drivers in the field that are not included in the literature review (attachment 1).

The observations in the field focus on the cassava value chain, since cassava is identified as a staple crop, which acknowledges that cassava is an important income resource and type of food that constitute the dominant part of the diet in Rwanda (FAO, n.d.; Nweke, n.d.). The observations are focused on the value chain since all actors in the value chain have an important role in the value chain (figure 8). It is also stressed by the Ellen MacArthur Foundation (2015 b) and by Jonker et al. (2018) that circular agriculture, requires a systems approach that includes different stakeholders of the value chain to create an integrated value chain. However, not all actors of the value chain can be observed in their activities. Therefore, the focus of the observations is on input suppliers, farmers/producers, middlemen (collectors), processors and retailers. It is also stressed in the literature that food waste or loss in developing counties occurs in two-thirds of production and handling storage of the food. In 2009, 39 percent of the food lost or food waste of countries in Sub-Saharan Africa happens in the production, 37 percent in handling and storage, 7 percent in processing, 13 percent in distribution and market and only 5 percent in the consumption (Lipinski, Hanson, Kitinoja, Waite, & Searchinger , 2013).

Therefore, the observations focus on input suppliers, farmers/producers, collectors, processors and retailers.

Table 5. Overview indicators and observations questions per circular economy principle. Source: Author's summary

Circular economy principle	Indicators	Observation questions
Principle 1 (P1). Design out waste and pollution	The actor use waste as input(s) for a new product(s) The actor uses by-products of the production process Biological materials are non-toxic	What does the actor use waste as input for new products or processes and for which purpose? *What has the potential to be used as input for new products or processes and why it does not happen (barriers) at this moment?*
Principle 2 (P2). Keep products and materials in use	The actor re-use materials, products and product parts The actor recycles materials, products are their belonging parts.	What does the actor re-use and for which purpose? What does the actor recycle and for which purpose? *What has the potential to be re-used/recycled and why it does not happen (barriers) at this moment*?
Principle 3 (P3). Regenerate natural systems	The actor uses renewable resources where possible	What kind of (renewable) resources does the actor use and for which purpose? *Which renewable resources have the potential to be used and why it does not happen (barriers) at this moment?*

Source: author

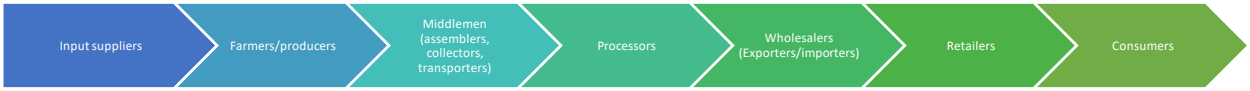

Figure 8. Overview of different actors in a general value chain. Source: author

Interviews

In addition to the observations, the researcher also conducted qualitative interviews to determine the current status of a circular economy in the field and to identify barriers and drivers for implementing a circular economy. The general input of this questionnaire is derived from the literature (table 6) and is transformed into a questionnaire for actors in the field (attachment 1). Interviews are conducted with a semi-structured/structured questionnaire that exists of open and closed questions. The rationale behind most of the closed questions (yes/no) is to identify if there is a need to ask other open questions. For instance, there is a question included in the questionnaire that asked: 'are there any laws/policies/regulations related to your (organic) waste, reuse of materials and recycling impact your business?' By yes, it is relevant to ask 'how do laws/policies/regulations related to (organic) waste, reuse of materials and recycling impact your business?' By no, it is not relevant to ask this question. This approach is used to simplify the interview procedure for the enumerator and to translate the questions, since the majority of the respondents of the 'informal cassava value chain' speaks Kirwanda. In addition, the questionnaire is designed in a simplified way so that actors are able to provide answers to the

questions. Despite the fact that the questionnaire has some closed questions, it does not have the purpose to test the data.

As stressed earlier, the interviews are conducted for qualitative purposes. Therefore, data collection becomes irrelevant when theoretical saturation is achieved in regards to the identification of new topics per actor (Bakers & Edwards, n.d.). Theoretical saturation can be defined as "process in which the researcher continues to sample relevant cases until no new theoretical insights are being gleaned from the data" (Baker & Edwards, n.d., p. 18). It is stressed by Morse (1995) that saturation is a good tool to achieve high qualitative research, however there are in the literature no clear guidelines or tests to estimate the sample size to reach saturation. Guest, Bunce and Johnson (2006) suggested that for high-level over-arching themes a sample size of six could be sufficient in order to develop meaningful themes and useful interpretations. However, Guest et al. (2006) suggest that a sample size of twelve should be a more appropriate sample size for among a group of homogenous individuals. Guest et al. (2006) found in their own research findings that saturation mostly takes place by the time that authors had analyzed twelve interviews. Therefore, this research strives to achieve a sample size of twelve per actor (input suppliers, farmers, middlemen, processors, retailers, wholesalers). Although, the actual sample size per actor also depends on practical conditions (time, resources and weather conditions) and how the different actors are represented in the field with the use of a snowball sample.

Selection

All actors of the observations and the belonging questionnaire are randomly selected and identified through a snowball method over different areas of the Kamonyi District, which is a district that is well-known for cassava in Rwanda. The interactive observations start with the farmers as actors since they are most likely high represented and easy to identify in the field. Other actors (input suppliers, processors, retailers etc.) are identified with a snowball effect through the reference of the farmers or other actors. Actors can only be observed if they are present in their working area. For example, an identified farmer that is on the market cannot be observed, since the farmer is not on the farm.

All data of the cassava value chain was collected with the assistance of local field enumerator(s), who had the role to translate the questions towards the actor and collect the data

of the questionnaire (attachment 1). The field data was collected through a technological data collection system (ODK) on an electronic tablet. During the observations also other data is collected, such the Global Positioning System (GPS), the name and distance of the nearest largest town, short description of the location, a picture of the location, remarkable or deviation information and researcher provide a short description of the location including the research units. Any other relevant observed details were collected in a paper-based notebook.

Table 6. Overview of questions per driver and barrier of each typology.

Construct	Barriers	Drivers	Indicator/operationalization	Question
Technical	Inappropriate technologies Lack of skilled workers, technical support, training and knowledge Path dependency in specialized knowledge-, technological skills and large investments in specialized technologies	Availability of technological solutions Research, capacity building through training to improve knowledge and skills Re-manufacturing and re-generation of by products as input to other processes, development of sharing solution with superior consumer experience and convenience	Degree of available technological solutions Available knowledge and skills about circular economy implementations Degree of efforts in research and development on circular economy activities	- Are there any research/extension/government institutions providing you with new information, training or technologies (communication, equipment, renewable resources etc.) to enhance your business? -If yes, what kind of organizations are providing support? -If yes, how do they support you? -If not, what could they do to support you?
Financial/ market	Large capital requirements and high initial costs Significant transaction costs Imperfect information Uncertain market New business models that are not proven hamper investments (planned obsolescence) Insufficient public goods/infrastructure Insufficient competition/markets Path dependency on previous long-term investments The economy is depending on export of natural resources Countries/SME's with financial challenges Circular models are depending on other business in one integrated value chain Circular business models are not profitable	Related to demand-side trends (rising resource demand and consequent pressure resource depletion) and supply-side trends (resource cot increases and volatility, leading to incentives towards solution for cost reduction and stability) Ecological economies Joint organization and alternative revenue models for circular business models	(Degree of) available business support schemes for circular business models (Degree of) available information for circular business models	-Are there institutions willing to lend you in the production of your product? (e.g. equipment, land, inputs) -If yes, what kind of institutions?
Institutional/ Regulatory*	Misaligned incentives Inadequate defined legal frameworks Poorly defined targets and objectives Implementation & enforcement failures Unintended consequences Changing governments with changing policies Lack of government investment capital/willing Insufficient public goods/infrastructure	Realigned incentives Clear direction & objectives Increasing environmental legislation environmental standards and waste management directives. Strategic roadmap Policy coherence between policies to support a circular economy Long term government plan that invest in new infrastructures and organization independent from government changes Regulations to encourage CE economy activities/discourage non-CE economy activities	Stimulating policy framework for circular economy activities Degree of stakeholder (especially business) involvement on policy building/decision making on circular economy activities	-Are there any laws/policies/regulations related to your waste, reuse/reduce of material, recycling or renewable energy that impact your business activities? -How do laws/policies/regulations related to your waste, reuse of materials or renewable resources, recycling impact your company? -Have you been involved/approached to provide input towards policies/regulations/norms? -If yes, how have you been involved?

Organization/planning	Different life cycles of products (long- and short term)	(Long term) planning and joint organization between partners in an integrated value chain that makes a distinction between long- and short life cycles of products Organization of an inclusive holistic approach of different stakeholders (farmers, businesses, interested citizen, researchers & government)	Degree of collaboration with other stakeholders/business partners in the (integrated) value chain	-Some companies are working together with businesses in the value chain, for example a company makes use of waste of markets to produce animal feed. Are you working together with other companies to produce your product? - If so, how do you work together with other companies in the value chain? -If yes, what are the challenges in this form of collaboration? -If yes, what kind of institutions? -If yes, how do they support you? -Are there any formal or informal institutions that support you with the cooperation between different stakeholders of the value chain? -If yes, what kind of institutions? -If yes, how do they support you?
Social/ cultural	Rigidity and path dependency of consumer behavior due business routines and environmental literacy Planned obsolescence	Awareness creation about circular economy and possible available choices, shifting consumer preferences (e.g. from ownership of assets to services models Social norms and communities Emotions	Degree of citizens/community involvement in awareness creation about CE activities	-What keeps your clients committed to buying your products? -Did you face challenges to attract customers for your products? If so, what makes the marketing of your products difficult towards the customer? -Are there any cultural or customer behavioral challenges for buying your product -If yes, what are the challenges? - Are there any community activities that encourage you to do something with your waste/recycle your waste that you generate during your business activities? e.g Umuganda, if so what kind of activities and how does it affect your business activities?
Environment	Recycling as a dominant circular economy discourse especially at practical levels	Focus on the other CE principals (reduce and reuse) in regulations and in businesses	Degree of circular economy alignment for all CE principles	- What type of waste is generated from your production process? -What happens to the waste that is generated from your business activities? -Do you use by-products/waste as input for your production process? -If yes, what kind of resources and for which purpose? -Do you re-use products in your production process? If yes, how and for which purpose? - Do you recycle in your production process? If yes, how and for which purpose? - Do you use renewable resources in your production process? -If yes, what kind resources and for which purpose?

Source: author's summery

Note: Descriptions are taken from journals, reports and other information resources that earlier described in this section, including information of table 3 and 4.

3.1.2 Survey

In addition to the interactive observation in the field, a survey was conducted with the objective to determine the implementation status of a circular economy of the 'formal agricultural sector' in East Africa. The survey was used to identify which determinants and interventions are relevant to accelerate the transition towards a circular agriculture in East Africa. In order to do so, formal companies were chosen as the target group of the survey, since companies are the most important practical implementers of a circular economy (Ellen MacArthur Foundation, 2015 b). The survey was conducted with formal agricultural companies with a circular business model (circular companies) and without a circular business model (non-circular companies). The survey was focused on business barriers and potential government interventions towards a transition to a circular economy. The first part of the survey is focused on questions related to the business model, barriers and drivers towards the operations of the company that are derived from the literature (table 6 and attachment 1). This part of the survey included the same questions as the interviews of respondents of the 'informal' agricultural sector with the purpose to collect complementary data about the formal agricultural sector.

The second part of the survey presented the identified barriers (table 7 and attachment 1) and potential government interventions of the literature review (table 8 and attachment 1) to companies in East Africa. As the objective is to identify and understand which barriers and government interventions are relevant for circular agriculture and not which barriers or policy interventions are more important in relation to each other, the respondents graded each business barrier and intervention on a Likert scale from 1 to 6. A six (6) indicates that the barrier is the highest important (great barrier), while grade one (1) indicates low or not important (Whalen et al., 2018). It is chosen to work with a Likert scale from 1 to 6, since it is stressed that a scale of six more reliable than a traditional 5 point Likert scale (Chomeya, 2010). Respondents have the opportunity to add comments by their ranking to explain why the formulated barriers are (not) important for their company. In addition, respondents were asked to fill in additional barriers/government interventions that are not covered in the survey with the purpose to ensure the quality of the final findings of this study (Whalen, Milios, & Nussholz, 2018). The identified barriers and government interventions are reformulated in a way that it was understandable for companies (attachment 3). Follow-up discussions took place via phone and email correspondence.

Sample size

Since this research was explorative, the sample size of respondents follows the same theory as the interviews of the cassava value chain, namely natural saturation. Theoretical saturation can be defined as a "process in which the researcher continues to sample relevant cases until no new theoretical insights are being gleaned from the data" (Baker & Edwards, n.d., p. 18). This means that the data of the survey was collected until natural saturation is achieved in the findings of the survey.

Furthermore, it is impossible to calculate the sample size of the survey of the 'formal agricultural sector (Isreal, 1992), since the total population size of the number of formal agriculture/agribusiness companies is unknown in East Africa. Since East African countries are developing countries it is not likely there is systemized and reliable data available about the number of agriculture/agribusiness companies for research purposes in a short term. Tanzania for instance, passed a Statistics Act in 2018, which says it is even a crime to collect and publish statistics that are not in line with the National Bureau of Statistics (The citizen, 2019). Despite that, the Act has dropped in June 2019, this act has created an environment that has decreased the freedom to share and publish (national) statistics (The Citizen, 2019). These factors hamper to collect accurate and reliable data towards the population size of the number of formal agriculture/agribusiness companies in East Africa. For these two reasons it is chosen to work with the natural saturation theory that strives to sample data until no new insights are found in the results.

Selection

All formal companies with a circular business model were selected for the survey with a snowball sampling method, since there is no authority/research done that has the data available about circular companies in East Africa. The snowball sampling method is a technique that is used to identify and contact the population that are hidden (Atkinson & Flint, 2011). Therefore, a snowball sampling is used to identify agricultural companies with a circular business model in East Africa. This methodology is initiated in every country by the identification of a set of circular companies through contacts of the researcher, searching on the internet and contacting the country representatives of the African Circular Economy Network (n.d.) per country. After the identification of the company, the company was contacted and a survey was conducted. In

order to identify other companies a question was included in the survey to request the respondent for other names and contacts of other agricultural companies in East Africa. All selected cases should be located in East Africa, for the consistency and comparability with other parts of this study.

The same snowball sampling method was also applied to select non-circular companies in East Africa. The snowball sampling method started in each country by the selection of a company that either does not know what to do with the waste or by a company that has the wish to implement a circular business model but is not started yet. Before the surveys were shared with the selected companies several test surveys were conducted in order to improve the survey and increase the reliability. All data is automatically collected through an online survey in Google Forms.

Table 7. Overview of barriers derived from the theoretical framework. Source: author's overview

	Type of barriers
B1	Inappropriate technologies
B2	Lack of skilled workers, technical support, training and knowledge
B3	Path dependency in specialized knowledge-, technological skills and large investments in specialized technologies
B4	Large capital requirements and high initial costs
B5	Significant transaction costs
B6	Imperfect information (inadequate/insufficient) available about the quality of the circular economy product/service for the buyer and seller, which negatively impact the quality of market decisions
B7	Uncertain market
B8	New business models that are not proven hamper investments
B9	Insufficient public goods/infrastructure
B10	Insufficient competition/markets
B11	Path dependency on previous long-term investments by companies
B12	Circular business models are depending on other business in one integrated value chain
B13	Circular business models are not profitable
B14	Lack of adequate defined policy frameworks with clear defined targets, objectives and incentives in policies
B15	Implementation & enforcement failures
B16	Unintended consequences of policies
B17	Recycling as a dominant circular economy discourse especially at practical levels
B18	Changing governments with changing policies
B19	Lack of government investment capital/willing
B20	Insufficient public goods/infrastructure
B21	Different life cycles of products (long- and short term)
B22	Rigidity and path dependency of consumer behavior due business routines and environmental literacy
B23	An economy that is based on planned hyper consumption

Table 8. Overview of government inventions derived from theoretical framework. Source: author's overview

	Type of government intervention
G1	Change educational systems (changes in educational curricula and manner of teaching) in order to train students for the next generation of creative problem solvers
G2	Training for professionals that are working in/related to agriculture about circular economy concept and circular agriculture practices
G3	Facilitate academic research to develop and improve (new) technologies and business practices through research experiments locations (test sites) and research budgets
G5	Establish collaboration platforms in order to share and develop knowledge and (technical) solutions, such as public-private partnerships between research institutions, universities, government and the private sector/ research & development programmes
G6	Demonstrate best practices to companies
G7	Establish pilot projects in an organization/company
G8	Information campaign for companies about circular economy practices
G9	Establish business support schemes for companies with a circular business model (like grants, subsidies, financial guarantees and capital injections)
G10	Initiate industry collaboration platforms (industrial symbiosis programmes) that have the purpose to develop cooperation in an industry where unused or residual resources of one company are used by another
G11	Initiation of voluntary (environmental) industry initiatives* in order to enhance environmental performance beyond existing legal requirements
G12	Facilitate sector-working groups in order to identify circular opportunities for businesses and consumers
G13	Business competitions with rewards to attract CE businesses
G14	Align CE ambitions and policies with stakeholders from the beginning
G15	Introduce regulations to encourage circular activities/discourage non-circular activities
G16	Introduce fiscal instruments that encourage circular business activities/discourage non-circular business activities
G17	Reduce taxes on labour
G18	Increase taxes on natural resources and pollution
G19	Establish a national portal for circular economy business models (in the agriculture) that services as a national counter for finding solutions towards difficulties in regulations of circular economy practices and to inform the private sector about financial instruments for circular innovations.
G20	Strategic roadmap with a coherent policy framework
G21	The government initiate/encourage small wins that are small, concrete and simple steps that can become the steppingstones towards the transition of CE economy
G22	The budgets of the public sector invest in circular economy activities
G23	Improve waste collection and recycling by establishing a waste & recycling infrastructure
G24	Awareness campaigns to the public and communities to inform them about the benefits of circular economy practices and products
G25	Institutional- and regulatory framework with a common ambition towards a CE economy that includes all principles.

3.2 Data analysis

Since this research has adopted a mixed research approach, the analysis has adopted two different ways of analyzing the data (Small, 2011). First, the data-analysis of the interactive observations (informal sector) is discussed followed by the survey of the formal sector in East Africa.

Interactive observations in the cassava value chain

The interactive observations and the belonging interviews have the purpose to determine the status of a circular economy in the 'informal agricultural sector' in the field and to identify barriers and drivers for the implementation of a circular economy. In order to do so, the analysis of the questionnaire uses a pattern-matching method, in which a literature review is utilized to

map empirical patterns in the research findings (Ranta et al., 2018; Saunders et al., 2009). In this study, this is done for the barriers, drivers and circular economy principles that are identified in the theoretical framework. For this purpose, the indicators of the barriers and drivers (table 6) are used to analyze the data towards barriers and drivers. For instance, if the data of a given respondent indicated that financial capital restrictions (or support) for the respondent, this was listed as a barrier (or driver) for the implementation of a circular economy. An indicator is identified as a barrier when it hampers the development towards a circular economy, while an indicator is identified as a driver, when it supports the development towards a circular economy. This approach is based on a study of Ranta et al. (2018) that used this methodology to identify barriers and drivers towards a circular economy.

This similar matching-pattern method was used to identify the status of a circular economy in the field by the utilization of indicators of the different circular economy principles (table 5). For instance, the data of the given respondent indicated that a respondent uses waste as input for animal feed or as the use of organic fertilizers, this was listed as implementing a circular economy in agriculture in line with circular economy principle 1 (table 5). Observations in the field are used to confirm the results of the circular economy principle. For instance, a processor stressed in the questionnaire that the company is not using biomass (renewable resources) in the processing activities, however, the researcher has observed that organic (biomass) waste is used as input for energy in the processing activities. These observations are used to check if the answers to the questionnaire are in line with the behavior of the actor.

It is important to note that the questionnaire exist of open and closed questions. In order to analyze the data of the open questions different coding strategies are used, such as open, axial, and selective coding (Boeije, 2014). The focus of the coding is to find patterns in the data of the different interviews. The software ATLAS is used for a systematic analysis of the different interviews. The data of the closed questions is presented in percentages in charts and are not statistically analyzed, which was also not the purpose of the data collection. In addition, the data of the closed questions are ordinal and nominal data with limited sample size, therefore it also not appropriate to use statistical analysis.

Survey

The analysis of the survey can be separated in two different ways of data analysis, since the survey has qualitative and quantitative data. First the analysis of the qualitative data is discussed, which is followed by a review of the analysis of the quantitative data.

a. Analyzing qualitative data

The purpose of this part of the questionnaire is to collect complementary data of the field observations with a different target group, namely 'formal' circular and non-circular companies in East Africa. This part of the questionnaire only exists of questions that provide qualitative data towards the sustainability of the company (circular economy principles, technical- and environmental factors), institutional support (policies/regulations, financial, knowledge factors) and questions related to cultural/social factors.

A similar analysis is used as the questionnaire of the cassava value chain, since a similar questionnaire of field observations is used to collect qualitative data for the survey towards circular companies. This means that also a pattern-matching method is used to analyze the qualitative data of the survey and that coding used to analyze the open questions. In regards of the closed questions, the majority of the data is nominal data since there is no logical order between the different categories. Consequently, only percentages can be calculated from the data. This means that descriptive statistics in the form charts and columns are used to represent the findings per question for circular and non-circular companies.

b. Analyzing quantitate data

As stressed earlier, this research has an explorative and theory building purpose, especially since this research is building on limited preceding research. The purpose of this quantitative data of the questionnaire is to measure the relevance of identified barriers and interventions for circular companies and non-circular companies (attachment 2, table 2 and 3). However, it was not the intention test different hypothesis, since this research has an explorative and theory building purpose. On top of that, it is not possible to measure the relevance of different barriers/interventions within the same group (companies), since there is no metric tool developed to measure circular economy as a dependent variable. Therefore, this study presented the importance of the different barriers and interventions in charts, tables, and percentages.

3.3 Validity and reliability

This paragraph discusses the roles of validity and reliability and towards which extend these concepts are accounted for.

Validity

Validity is about the question of whether the research truly measures what it should measure and how truthful the findings of the research are (Golafshani, 2003). The concept validity can be separated in internal and external validity. Internal validity is about the question of whether the researcher measured what it should measure, hereby it refers to what extent the methodological research design can provide evidence to test the possible causality between the independent and the dependent variable (Lavrakas, 2008). External validity questions the generalization of the results towards other situations, times, countries and organizations. It is concept is also formulated by Yin (2009) as defining the domain to which extend the findings can be generalized.

Since this research makes use of multiple ways of data collection, this thesis discusses how validity plays a role in the different ways of data collection. First of all, the interactive observations of the 'informal sector in Rwanda' is a case study since it focuses on the cassava value chain in Rwanda. Although some scholars are skeptical about the lack of generalizability of case studies, case studies are useful to provide a high internal validity and in-depth understanding, which was the purpose of this study. However, this study confirms the answers to the interviews of the 'informal sector' by observing the respondents and their working area. Furthermore, complementary data is collected through a survey with the 'formal agricultural sector' in East Africa. This is also called data-triangulation, a concept whereby the collection of multiple resources results in an increased validity of the result findings (Yin, 2009). Since this study uses multiple ways of data collection (interviews, observations and surveys) through different East African countries, the external validity of the research findings increases.

Bias of the researcher

Within research there are three types of interruptions that could disturb the validity and the reliability of research, namely the bias of the researcher, the research method /operationalization of the research during data collection and analysis, and the research units. According to

Simundic (2013, p. 12) a bias is “any deviation or trend from the truth in data collection, analysis, interpretation, and publication which can cause false conclusions”. Simundic (2013) stresses that a bias can happen by intention but also unintentional. It is important to stress that every researcher has their own scientific opinion, towards doing research. This involves to recognize the bias of the researcher towards the research design, the way of data collection, analysis and interpretation of findings.

Sapsford and Jupp (2011) underlines that the bias of the researcher could play a role by conducting observations, since the observations are done through the interpretative lens of the researcher. Therefore, Jorgensen (1989) stresses that it is not possible that the observations provide the research with a direct representation of the reality. Furthermore, the researcher has to filter what they observe and need to select what to report, therefore it could be a risk that the own expectations and the knowledge of the researcher could influence (bias) the findings of the observations (Sapsford & Jupp, 2011). In order to reduce the risks a standardized observation scheme based on literature is used with the objective to focus on the same aspects during all the observations (attachment 1). Triangulation is used to check the findings of interviews with the observations. On top of that, the observations are multiple times replied with different actors of the cassava value chain over several areas of Kamonyi District.

Another factor that could bias the research findings is the (self) selection bias of the researcher. A selection bias refers to the manner that study objects are recruited or the rates of study participation depend on the cultural background, age, social-economic status of study objects (Hammer, du Prel and Blettner, 2009). In this research a snowball sample size method is used for the selection of the respondents of the ‘informal agricultural sector in Rwanda’ and the ‘formal sector in East Africa’. This sampling method can be criticized for selection bias, which could limit the validity of the sample since the samples are not randomly selected (Atkinson & Flint, 2011). However, there are no other proper sampling size methodologies available, since there is no data available to find the hidden populations of the ‘informal’ and ‘formal’ sector. Moreover, the overall research is explorative research and is relying on limited research, therefore there are limitations in the study and availability of data. The interactive observations with the interviews are conducted in different areas of the Kamonyi District with the objective to reduce the risks of the selection bias. Furthermore, the interactive observations (interviews) are

done with the assistance of an enumerator who is able to translate Kirwanda and English with the purpose to avoid self-selection due to linguistic barriers of the researcher.

Operationalization of the research

Every researcher can make mistakes by the development of the research design and to apply a valid and reliable methodology. In order to reduce the risks and increase the reliability (the possibility to repeat and replicate research) the researcher can incorporate different measures (Golafshinani, 2003). This study makes different efforts to incorporate a systematic way of working, since it makes use of structured observation schemes, semi/structured questionnaires to conduct interviews and surveys with the respondents, and the utilization of different software programmes for a systematic data collection and analysis. Furthermore, this study also took measures to increase the reliability and validity. The questionnaires of the interview and the survey are tested and evaluated before the research was conducted. In addition, the questionnaire of the interview of the 'informal sector' was discussed with the enumerator in advance to avoid translation mistakes in the field.

Furthermore, the interactive observations were done throughout an entire value chain and was repeated with different actors with the objective to increase reliability. In order to increase the reliability of the survey, respondents were asked to fill-in additional barriers and interventions in the survey that hampers their company operations. Following that, the respondents were also asked to include additional government interventions to overcome the identified barriers. In addition, all respondents of the survey are based in East African countries with relatively comparable food systems and formality and informality of agricultural actors in order to increase the comparability of the results. In the methodology all steps of the research are described in full detail, which means that the research can be replicated.

In order to increase the reliability of this study, this research makes use of proven methodologies to investigate barriers and policy interventions in other studies about circular economy cases in Sweden (Whalen et al., 2018). However, Whalen et al. (2018) decided to include interviews and literature review as input for the survey, this study decided to include interactive observations and literature reviews as input for the survey which is done for two different reasons. First of all, companies have a time limit that they are willing to contribute to research, which provides the risk that the respondents drop out in intensive research. Secondly,

the majority of the agricultural sector in East Africa is informal and primarily based on smallholders with traditional knowledge about farming practices, which means that interactive observations can identify other barriers and drivers that are not identified in the literature or in the interview.

Research units

On top of that, the research units can also interrupt the research. In the interactive observations the research units (actors of the cassava value chain), might change their behavior either consciously or unconsciously. It is stressed by Sapsford and Jupp (2011), that this might result an inaccurate representation of the natural behavior of the actors. However, the researcher was mostly focused on the circular economy principles in the field (table 5), which makes it easier since it does not always require the direct action of the actor. For instance, a collector that is drying the waste of the cassava as input for animal feed is not able to move the waste without noticing it during the observation. Another illustration included a retailer that is on the market to sell cassava in a recycled agricultural bag is not able to remove the bag, since the retailer needs the bag to sell cassava. In addition, triangulation is used to confirm the findings of the observations with the interviews and observations are repeated with different actors (Sapsford & Jupp, 2011).

Another aspect that is stressed in the literature is the social desirability of the respondents during an interview and survey. Social desirability is the tendency of a respondent to answer a question in such a way that the respondent thinks that it is more socially acceptable than their actual answer (Lavrakas, 2008). A survey is especially sensitive to this issue, which can be solved by the inclusion of clear questions and instructions with examples. Therefore, this research has tested the survey and the interview with the aim to improve the questionnaire before the final data collection was started. Furthermore, the questionnaire has included examples by the questions for clarification. Another measurement that can be implemented is to include control items in the questionnaire with the purpose to test the consistency of the answers of the respondent. Therefore, this study includes a set of questions that have some overlap with each other. For instance, the question; ‘could you give us as an overview on the different products/services that your company offers around agriculture/food systems’, can already indicate the type of input that is used in the business activities of a circular company, while this

also asked in the questionnaire by ‘do you use waste as input is in your business activities?’ if yes ‘what kind of waste do you use? if yes ‘for what purpose do you use the waste in your business activities?’ Another example is the question: Are there other sustainable practices/technologies that you implement in your company? If yes, how do you implement it and for which purpose’, could indicate if there are any missing items that are not in line with the questions what happens with the waste, recycling, etc.

In addition to the issue of social desirability in a survey, a survey can also face challenges towards the non-response of invited respondents. This can result into less representative sample size and reduce the external validity. In order to reduce the likelihood of this event, the researcher has developed three strategies. First of all, the researcher contacts a key person with a network of circular/non-circular companies through the snowball sample method. The researcher asks the key person to introduce the researcher by the futuristic respondent, which reduces the likelihood that the respondent does not respond on the request of the key person. Secondly, there is no research done about circular economy in agriculture in East Africa, therefore the researcher can offer a unique research report that is especially useful for circular companies and non-circular companies that are interested in the circular economy. The third strategy is that researcher makes an appointment with the company, either in person (if possible) or through phone, which requires the respondent to fill in the survey immediately.

4. Research results and analysis

This chapter presents the research findings of the interactive observations of the cassava value in Rwanda and the survey that was conducted with circular/non-circular companies in East Africa. The first paragraph (4.1) discusses the demographic data of the respondents of the informal and formal agricultural sector. The status of a circular economy in the Rwandan 'informal' and East African 'formal sector' is further presented in the second paragraph (4.2). Furthermore, the implementation barriers (paragraph 4.3) and solutions (paragraph 4.4) to establish a circular economy are discussed. After that a brief summary is presented with the most important findings (paragraph 4.5). In this section quotes of respondents in the 'informal' and formal sector are used in the text. In respect of the privacy of the respondents there are no names used by the quotes. Quotes are used as close as possible to the original quotes of the respondents, therefore quotes are not always perfectly formulated.

4.1 Demographic data

This paragraph presents the demographic data of the interviewed respondents of the 'informal sector' interviews in Rwanda (Kamonyi district) and the respondents of the 'formal sector' in East Africa with the objective to explain uncovered patterns in the data. All questions of the 'formal sector' are answered by 26 respondents, which are all used for the data analysis (attachment 5). The majority of the questions of the 'informal sector' are answered by all 82 respondents, the data of 80 respondents could be used. The answers of two respondents could not be used, due to missing and incomplete data from a technical failure and a small mistake of the enumerator. The question 'are there any institutions willing to lend you to improve your business?' is answered by 53 respondents, since this question was not included in the ODK system on the tablet from the beginning due to a technical failure. Although natural saturation is reached for every actor. The overall number of non-responses for the 'informal' sector in Rwanda and 'formal sector' in East Africa (Rwanda, Tanzania and Kenya) is quite low, which results in to high representative research findings with a high external validity (table 9).

The respondents of the formal companies are mainly located in Rwanda and in Tanzania, since the snowball methodology was more successful due to the physical presence of the researcher and opportunities to follow up with the respondents (figure 9). Remarkable is that 42 percent of the respondents are active in horticulture, 15 percent of the companies in the

production of animal feed and compost/organic fertilizers (table 10 and attachment 5). Furthermore, 64 percent of all respondents are owner/manager of a company that is younger than five years (figure 10).

Table 9. Overview of number of responses the (in) formal sector.

	Rwanda	East Africa
Total number of responses	82	26
Total number of non-responses	2	2
Total number of responses that are used	80	26

Source: author

Table 10. Overview of the representation of the different agricultural subsectors by the respondents in East Africa. Source: author

Sector	Representation in percent
Horticulture	42.3
Livestock/poultry	7.7
Compost/organic fertilizer	15.4
Agribusiness	7.7
Animal feed	15.4
Input supplier	7.7
Other	3.8

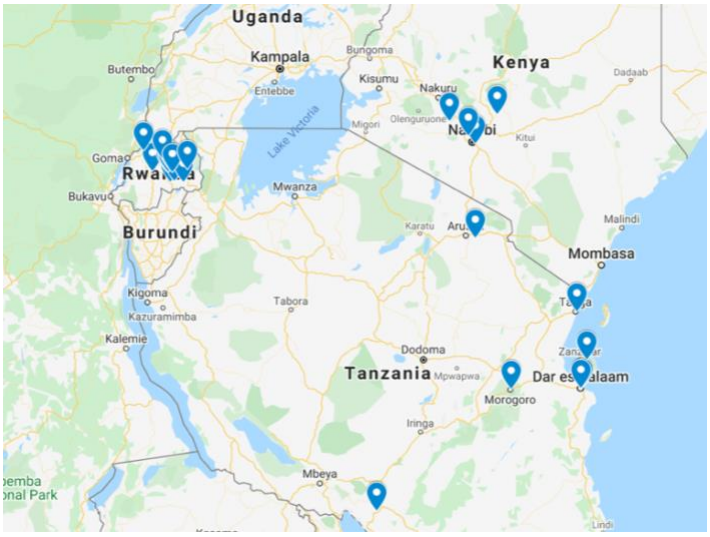

Figure 9. Overview of the location of the respondents of the formal sector in East Africa. Source: adapted from Google Maps

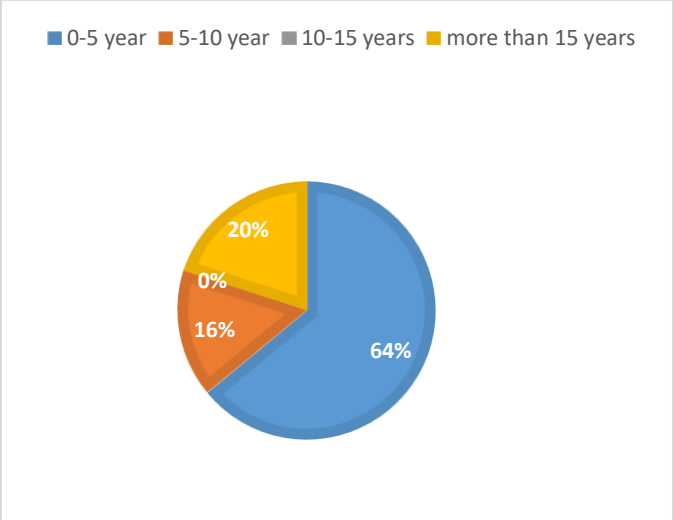

Figure 10. Overview of the number of year's existence of the respondents' formal company in East Africa. Source: author

Furthermore, in the 'informal agriculture' there are also certain patterns in the distribution of the respondents in data. Before that is discussed a photo overview of different actors in the informal cassava value chain is presented in attachment 4. Farmers are higher represented (table 11) in the field than other actors and located in remote areas to produce cassava and other crops based on traditional methods (figure 10). Similar as the farmers, collectors can be seen in more remote areas to collect cassava from the farmers to sell cassava to customers/processors, although the numbers of collectors are limited to make a hard statement. Retailers are based in more urban/village areas as well in remote areas to sell crops as cassava flour and other products to

citizens. Input suppliers are mostly located around local markets, since input supplier sell inputs (fertilizers, pesticides, medicines for livestock) to farmers. Similar to input suppliers, traditional processors are based around local markets to process cassava of the farmers into cassava flour. An exception can be made for one modern processor, which has a modern factory to collect and process cassava into cassava flour based in a more rural area.

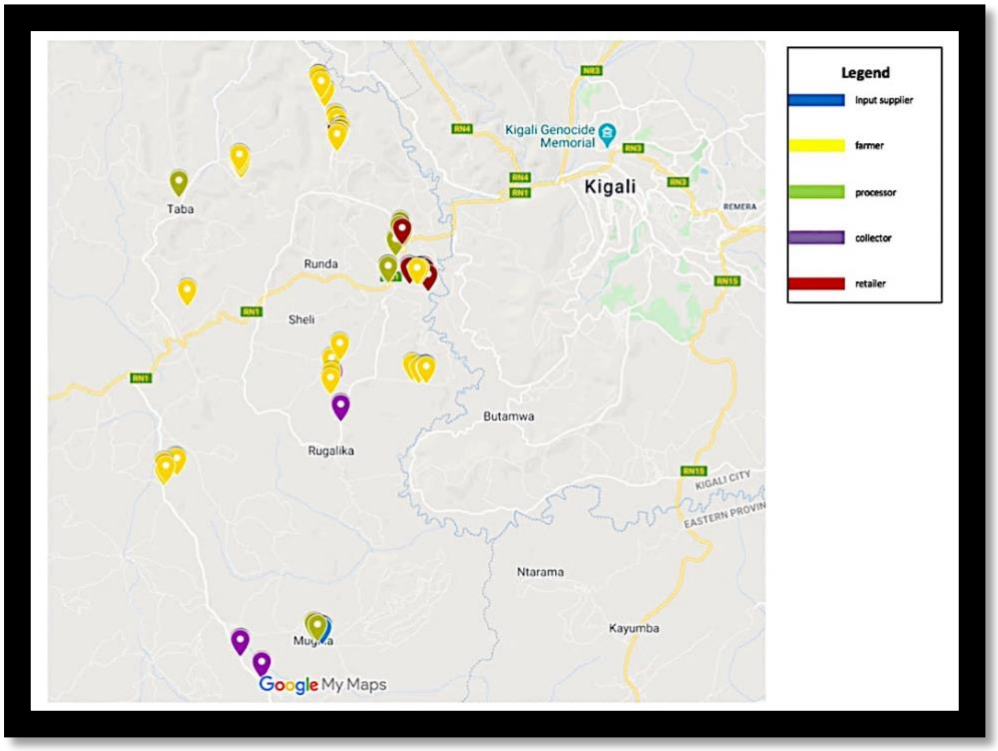

Figure 11. Overview of the locations of the respondents in Kamonyi, Rwanda. Source: adapted from Google Maps.

Table. 11 Overview of the representation of the different actors of the informal cassava value chain in Kamonyi, Rwanda.

Type of actor	**Percent**
input supplier	10
farmer	46.25
collector	12.5
processor	13.75
retailer	17.5

Source: author

Remarkable is the difference in the level of education between 'informal' and 'formal sector'. Only 13 percent of the respondents accomplished secondary school completely, while more than 92 percent of the 'formal sector' has at least an accomplished a bachelor degree (table 12). It is noticeable that the Rwandan school systems make a difference between secondary junior (ordinal level) and senior secondary (advanced level). As a result that that some of the respondents have completed primary school a junior secondary school, but did not accomplish secondary school completely (U.S. embassy in Rwanda, n.d.).

Table 12. Overview of the highest level of accomplished education by the respondents of the formal and informal agricultural sector.

	Informal sector Rwanda in percent	Formal sector East Africa in percent
Drop out / no school	14	0
Primary school	73	0
Secondary school	13	3.8
Bachelor	0	57.7
Master	0	30.8
PhD	0	3.8
Dr.	0	3.8

Source: author

4.2 Status of a circular economy in the informal and formal agriculture in East Africa

This paragraph presents the research findings in East African informal and formal food production systems based on three earlier mentioned circular economy principles (paragraph 2.1), namely design out waste (4.2.1), re-use of materials (4.2.2) and regenerative systems (4.2.3).

In order to calculate the percentages of the status of a circular economy for both respondents' groups, the respondents are asked questions about circular economy practices (attachment 2 and 3). For instance, in case the question 'do you recycle in anything in your business activities?' is answered with 'yes' the number of respondents that answered 'yes'/'no' are counted. A percentage is calculated over the total informal/formal respondent group (paragraph 4.1) that answered 'yes'. The 'informal sector' also present percentages calculated per actor (paragraph 4.1) within the 'informal sector', since every actor has a different function in the value chain.

4.2.1 End-use of different types of waste

As shown in figure 12, 90 percent of all respondents of the 'informal sector' generate organic waste in their business activities. Especially farmers, collectors, processors and retailers produce organic waste in their activities (table 9). Liquid waste is mostly produced by collectors and by processors with a modern factory since water is used to wash the cassava. Traditional processors do not apply liquids or only use limited water quantities. Plastic waste is mostly produced by input suppliers (44 percent) and retailers (43 percent), while paper waste is mostly produced by input suppliers. About 56 percent of all input suppliers generate other types of wastes, such as the tin package material of seeds and agricultural bags/sacks. Other types of waste that are

mentioned by farmers/collectors or retailers is cow dung, human waste or the left-over of soils of unwashed potatoes. The quantities of different types of waste are included in attachment 6.

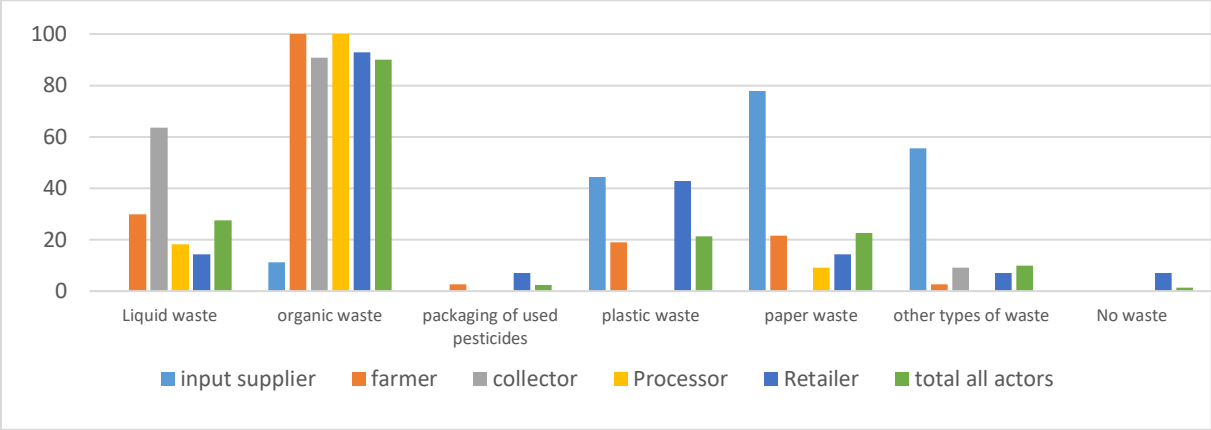

Figure 12. Overview of different types of waste in percentage per actor of the 'informal' cassava value chain in Rwanda. Source: author

Similarly, to the 'informal sector', organic waste is high presented in the 'formal sector', since 65 percent of all respondents of the 'formal sector' generate organic waste in their business activities (figure 13). Most of the waste that is generated by the 'formal sector' is used as input compost/organic fertilizers, energy or as animal feed (figure 14). About 23 percent does not generate waste, which means the respondents use organic waste as input for their business activities.

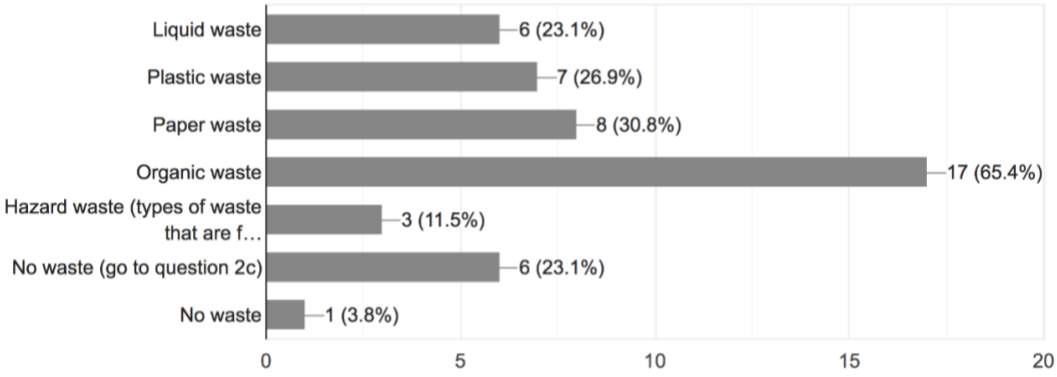

Figure 13. Overview of different types of wastes that is generated by formal companies in East Africa. Source: author

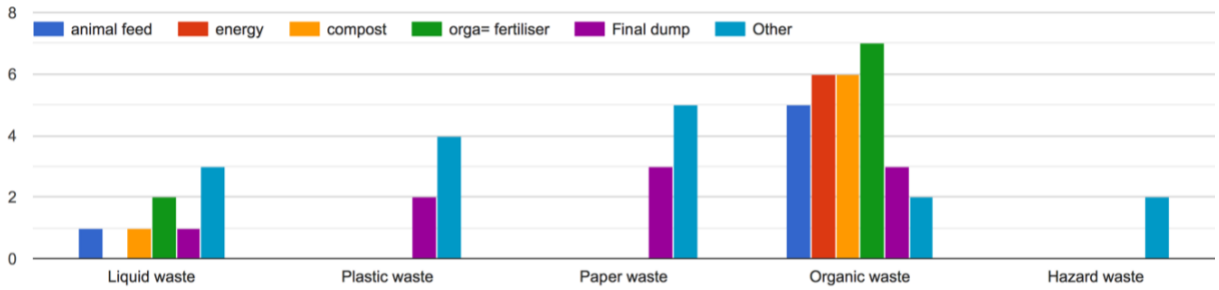

Figure 14. The end-use of different types of waste indicated by the 'formal sector' in East Africa. Source: author

Liquid waste

About 28 percent of the total respondents of the 'informal sector' generate liquid waste of the 'informal sector', which is almost equal to the 'formal sector' (23 percent). Liquid waste is mostly generated by collectors and modern processors of the 'informal sector' (figure 15). Furthermore, ten percent of the liquid waste is used as compost, while fifty percent of all liquid waste of the collectors is dumped (figure 15). It is important to note that all actors can use waste (liquid, organic, plastic and paper) in more than one way, which can be seen in the different figures.

In the 'formal sector' liquid waste is mostly used for other purposes such as recycling of water in modern farming technologies such as hydroponics and vertical farming. For example, one agro-processing company has established its own wastewater plant. Besides, the use of liquid waste for other purposes, liquid waste is also dumped and utilized as input for animal feed or compost (figure 14). One respondent of a milk processing company stated that expired milk is sold to farmers with pigs. Furthermore, the same company has established a water recycling plant to recycle water. Some companies utilize liquid waste in more than one way, for instance water included with fertilizer is recycled in a vertical farming system.

> "We are practicing hydroponics where we are using about 90% less water than in traditional open field. This also means there is less fertilizer run off and pollution in the ground. We also practice vertical farming so this means that we use less space". – Startup in vertical farming

> "We have a waste-water plant to clean the water of our processing activities, to remove chemicals and to release the water. So water is treated". – Agro-processor

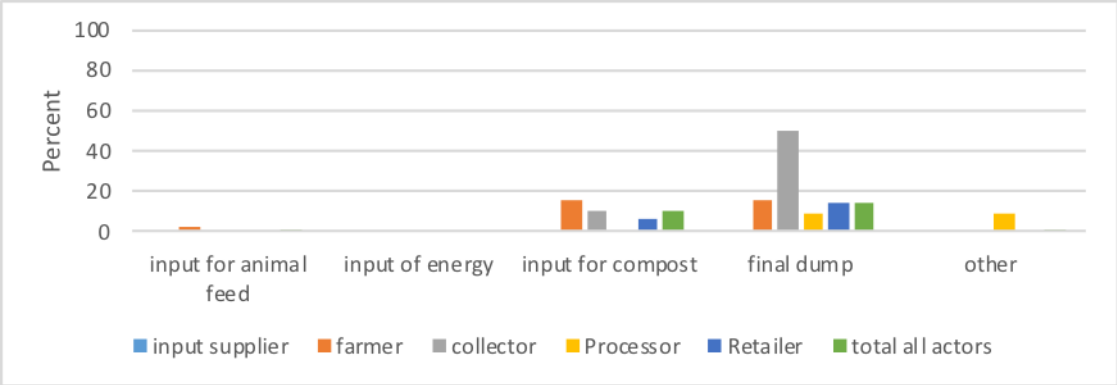

Figure 15. Overview of the end use of the liquid waste per actor of the cassava value chain. Source: author

Organic waste

Organic waste is the highest presented type of waste by the 'informal' (90 percent) and the formal sector (65 percent) (figure 12 and 13). As shown in figure 16, about 91 percent of all interviewed processors of the 'informal sector' use organic waste for animal feed of their own animals or to sell it as animal feed to farmers. On top of that, 100 percent of farmers use organic residues for compost and 46 percent of the farmers use organic waste to feed their own animals.

> "Organic waste is used as input for compost and for animal feed, I dump plastic waste. Compost is made from a mix of organic waste with maize and manure of the cow. Waste of the beans is used as bedding for the cow, when the cow sleeps – farmer".

About 30 percent of the respondents work together with other actors related to their organic waste. For instance, 19 percent of the farmers work together with fellow farmers in order to receive compost or to sell/provide compost free. In some cases, farmers have an exchange relation with fellow farmers whereby the farmer provides something for free (like animal fodder, which is a type of animal feed) and the farmer receives something back for free (like animal manure). Moreover, fifty percent of the collectors work together with farmers related to their organic waste. This is mostly accomplished by selling or providing organic waste for free to farmers, which is used as animal feed or as compost. Furthermore, 82 percent of the processors sell organic waste as animal feed, while 18 percent of processors sell organic waste as input for compost made from organic residues of processing activities. One processor stated that organic waste (cassava waste) of neighbors is collected to process waste into animal feed (figure 17).

"Pay cash or I give them animals fodder they give me manure back. If I don't have grass I need to pay, if I do not pay I do not receive manure." - Farmer

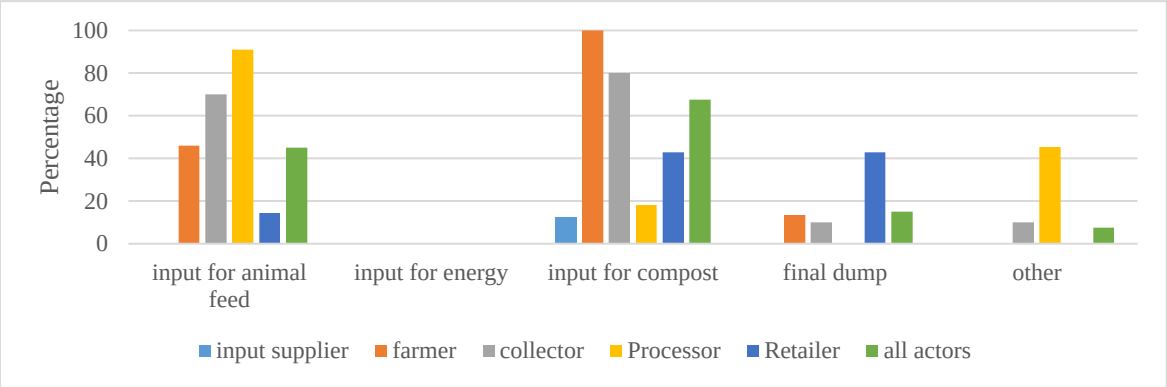

Figure 16. Overview of the end-use of organic waste per actor of the informal sector. Source: author

Figure 17. Farmers peel cassava in Kamonyi district, Rwanda. The peels are considered as waste, however, peels can be used for different circular innovations. Source: author

Remarkable is that 44 percent of the retailers dump the organic waste in their neighborhood or village (figure 16), only one retailer works together with farmers to provide organic waste as animal feed. In addition, 10 percent of the collectors dump organic waste and 13.5 percent of the farmers dump their organic waste (figure 16). Some of the farmers stated that some organic waste used as animal feed, while other organic waste is dumped.

"I dump organic waste around here, it just a shop not my home". - retailer

It is also noticed in the observations that the local markets produce organic waste, which is collected at the end of the day (figure 18). Every market in Kamonyi district has their own coordination and manners of waste collection. In some cases, a waste collector provides a free waste collection point so that actors can produce compost (Ryuenzi market), while another market (Mugina market) just arranged their 'market' dumpsite for waste so the market can add value to the waste in the future. Furthermore, another market has arranged its waste collection through a family that collects waste and brings it to the dump side. Farmers and other waste collectors collect the waste from the dumpsite for free with the purpose to add value to the waste.

Processors also see value in waste collection. About 82 percent of the processors stated that there could be a business opportunity to process organic waste into other products such as organic fertilizers or animal feed. It stressed by some processors that it is possible to process waste into other products, so long it brings more profit than selling waste directly to farmers. One modern processor with a large facility stressed that it could be a business opportunity that farmers receive discounts on high-quality animal feed by peeling cassava.

Figure 18. Waste collection from the local market in Kamonyi district, Rwanda. Source: author

Similarly, as the 'informal sector', organic waste is also mostly used as compost/fertilizer and as animal feed in the 'formal sector' (figure 14 and 15). Furthermore, organic waste in the 'formal sector' is used as a source of energy (figure 15). In addition, the 'formal sector' uses waste as input for their business activities, which means that organic waste is actively collected as input for business activities with the aim to transform it in another product. For instance, companies collect organic waste to process it into compost/organic fertilizers or to produce animal feed by growing black soldier flies on organic waste. About 96 percent of the respondents

use organic waste as input in their business activities, which is used for different purposes (figure 18). About 35 percent of the respondents have an ‘in-house circularity model’, which means that the company ensures the closure of cycles within the company itself (Jonker et al., 2018) (figure 19). Examples that are found in this study include the recycling of bread crumbs of own produced cassava again in the production process, the use organic waste from a restaurant to their own farm by composting organic waste to produce fertilizers for crops for their restaurants, vertical farming that aims to recycle water and fertilizers, and the use of organic waste to produce biogas for own company usage.

Furthermore, 15 percent of companies make use of ‘partial chain integration’ which means that the residue of one business process is used to produce a separate product (Jonker et al., 2018). Examples in this study includes a company that collects organic waste from restaurant to grow insect-based animal feed for its own free-range farm, or the collection of organic waste from farmers to produce compost to grow mushrooms. About 31 percent of the respondents have other forms of circular business models that aim to design a circular end-product, which are companies that grow insect-based animal feed for farmers, produce compost or organic fertilizers. The other companies have a not circular economy business model for waste yet but have plans to implement circular solutions.

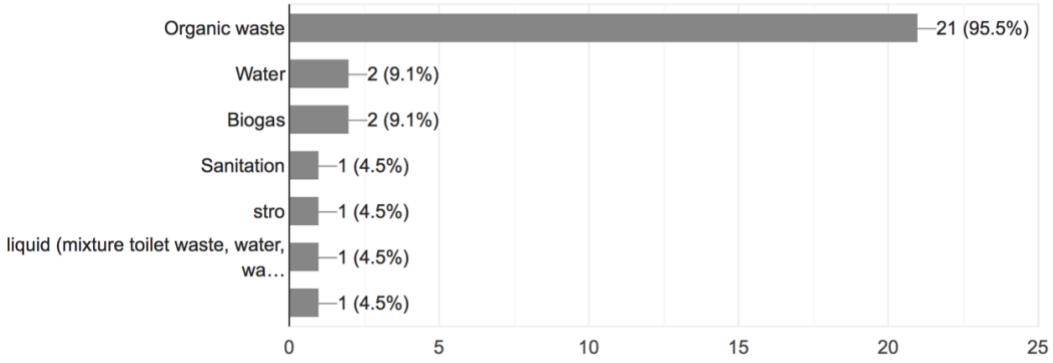

Figure 18. Overview of different types of waste that is used as input in the business activities. Source: author

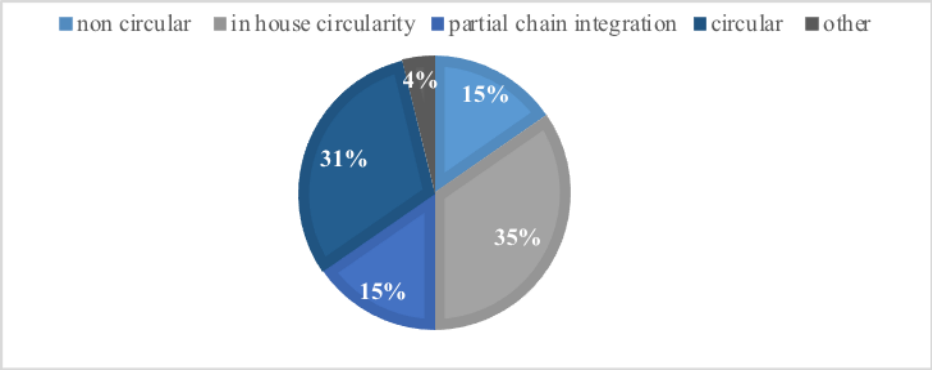

Figure 19. Overview of different types of business models of the respondents of the formal sector that use waste for different purposes. Source: author

Plastic waste

Besides organic waste, there also other types of waste produced in agriculture in East Africa such as plastics. About 21 percent of the respondents of the 'informal sector' generate plastics in their business activities compared to 27 percent of the respondents of the 'formal sector' (figure 14). As can be derived from figure 12, plastics from the 'informal sector' are mostly generated by input suppliers (44 percent) and retailers (43 percent). Actors either dump their plastics (9 percent of all actors) or 12.5 percent use it for other end destinations. Farmers and retailers indicated that they do not use plastics for other purposes, but that they burn the plastics when they are no longer usable. About 38 percent of input suppliers use plastics in other ways, such as providing plastics for free for storage of home products (e.g. sugar), collected informally for free by a person who sells the plastics to users or plastics are burned (figure 20).

> "I burn plastics". – input supplier

Plastics in the 'formal sector' are either dumped or used for other purposes such as recycling (figure 14). For instance, one respondent processes different types of waste (including organic waste) to add value to products or raw materials for recyclers. In this case, plastics are processed into smaller plastics for other recyclers. Other companies provide plastics, such as bags and bottles to companies that recycle plastics.

> "Plastics generated by our company are recycled into plastic bags by another company, incl. bottles. The company is giving us some money". – Tea production company

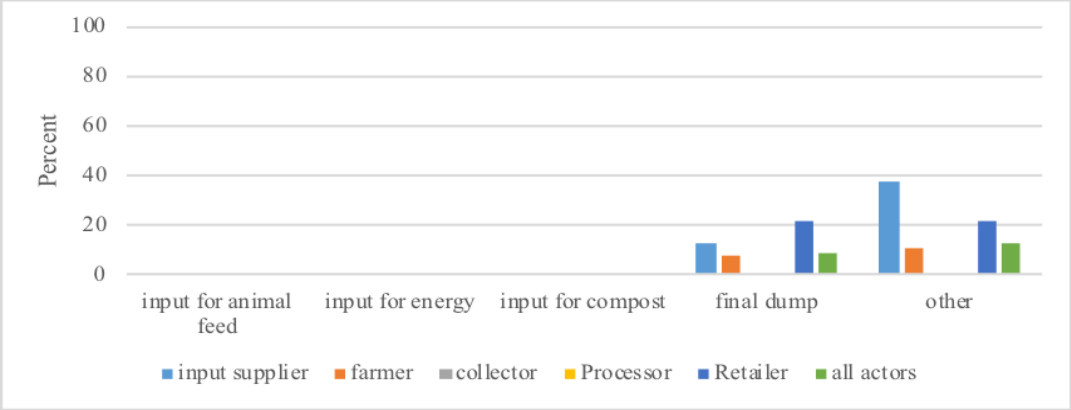

Figure 20. Overview of the end-use of plastic waste per actor of the 'informal' cassava value chain. Source: author

Paper waste

Paper waste is generated by 23 percent of the 'informal sector' compared to 31 percent of the respondents of the 'formal sector' (figure 12). As mentioned earlier, paper waste of the 'informal sector' is mostly produced by input suppliers (figure 21). About 63 percent of all paper waste that is generated by input suppliers is utilized for other purposes. In most cases papers are burned or used to make paper bags from old papers for selling products to customers (figure 21). It is also observed that input suppliers sell products to customers in paper bags made from old papers. Remarkable is that about 8 percent of all farmers use papers as input for compost. In the 'formal sector' papers are either dumped or used for other purposes, such as recycling (figure 14). Respondents of the 'formal sector' stated that papers are recycled and provided to other recyclers as raw material or other companies that collect papers for recycling.

"I dump paper waste and agricultural sacks around the market". Input supplier

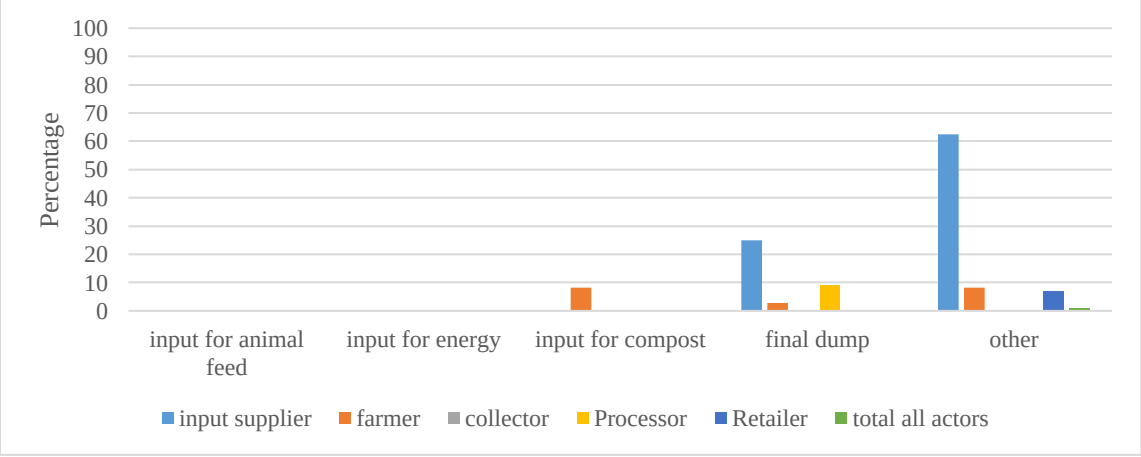

Figure 21. Over of the end-use of paper waste per actor of the informal sector. Source: author

Collaborations related to the end-use of waste

As stressed earlier, about 38 percent of the respondents of the 'informal sector' work together with other actors related to their waste (figure 22). These collaborations have a focus on organic waste, since 30 percent of these collaborations are based on organic waste. In contrast, almost 81 percent of all respondents of the 'formal sector' in East Africa work together with informal or formal companies related to waste or recycling, which is a significant difference.

There are eight different ways of collaborations identified for the 'informal sector' (figure 24). The first form of collaboration is the pick-up of different types of waste by a company from retailers by paying a waste collection fee. The local government plays an important role to control if actors comply with the waste collection fees. Secondly, informal waste collection happens by collecting waste by unemployed people who collect waste for free (plastics, paper etc.) from input suppliers and sells it. Thirdly, waste is collected for free by actors that request waste from input suppliers are retailers. This includes agricultural bags and organic waste that are given to farmers for compost or animal feed, and customers that are asks for waste such as plastics and tin packaging of seeds.

> "Farmers are coming to pick-up organic waste in order to produce organic fertilizers for the farm. People come to collect the canned packing waste of the seeds. The packing of the seeds is provided for free to people who recycle. The people who are collecting are not the ones that are recycling. It is recycled for what-ever they want to do with it". – Input supplier

In addition, waste is also sold, which includes agricultural bags and organic waste that is used as compost or animal feed. Processors often sell organic waste as animal feed. In one case, a modern processor was observed selling compost and providing discounts to the farmers that come to peel cassava at the processing facility. Furthermore, some respondents buy human waste as input to produce human waste fertilizers. These human waste fertilizers are sold through cooperatives and directly to farmers. In addition, farmers or processors use their own organic waste as animal feed or compost. At last, farmers have barter exchange collaborations with fellow farmers where one item is given for another item. For instance, a farmer provides animal fodder (grasses) and receives organic waste in return. The most frequently observed relations related to waste is the use of organic waste by the respondent's sale of organic waste (figure 25).

> "Pay cash or I give them animals fodder they give me manure back. If I don't have grass I need to pay, if I do not pay I do not receive manure." - Farmer

There are five different ways of collaborations identified related to organic waste and recycling practices in the 'formal sector' (figure 23). First of all, formal waste collection through another company is one of the most frequently identified relations. Formal waste collection takes places for two different purposes. First of all, waste collection is done in order to simply pick up waste from the company. Secondly, waste collection takes place with support from a waste collection company with purpose to add value to the waste. For example, waste is collected by one company, while another is responsible to make compost/organic fertilizers from the waste. One respondent stressed that the local government supports interconnection between the different companies to establish collaboration whereby one company picks up the waste, while the other company makes compost from the waste.

> "Collaboration is under progress. The district helps us to connect with other companies and share responsibilities and task related to waste; pick up waste to dumpsite and we make the organic fertilizer by the dumpsite from organic waste of the dumpsite". – Company that produce organic fertilizers.

Secondly, formal waste collection takes place by the pick-up of waste (paper and plastics) from companies or the use of the informal business people to collect waste for value addition. Informal waste collection is one of the most frequent indicated relations with other actors related to waste and recycling. Thirdly, companies collecting waste from restaurants or industries to add value to it. For instance, a company in Rwanda collects organic waste for free from restaurant to produce insect-based animal feed (black soldier flies) for a free-range farm and in return the farm sells the end products (eggs and meat) back to the restaurant for a good price. Waste collection by the companies itself also takes place through informal waste collection. For instance, an organic farm in Zanzibar collects coconuts from informal business people on the street who sell coconut drinks in order to make mulch that is applied to the soil. Furthermore, companies also buy waste to add value to the waste. For instance, waste is collected from local breweries to grow black soldier flies on the waste or waste of beekeepers is collected to make soap from the waste. There also are two companies identified that collect waste from other industries, markets, etc. to grow black soldier flies as animal feed, although it cannot be derived from answers from respondents if they collect waste for a fee or buy the collected waste from other actors. At last, companies also sell organic waste to different actors. For example, waste sugarcane is sold as

animal feed to sugarcane farmers for a low price. As a result, that the company receives sugarcane for a local price.

> "Organic waste of coconuts are used as a mulch on the farm. The mulch is put on top of the soil so that it integrates in the soil slowly. We are working with the persons who are selling the coconut drinks on the streets". – Organic farm

An important difference between the results of the 'informal sector' and 'formal sector' towards the collection of organic waste is the focus on waste collection as input for business activities. In the 'formal sector' 11 respondents of the 26 respondents (figure 24) collect waste as input for business activities (42 percent) compared to two – four respondents of 80 respondents (not more than five percent) (figure 25). It is not clear from the data by two of four respondents if the respondents of the 'informal sector' collect waste as input to compost or that the respondents use their own waste as input to produce compost. Although, the great difference in the data between the 'formal and informal sector' is clear.

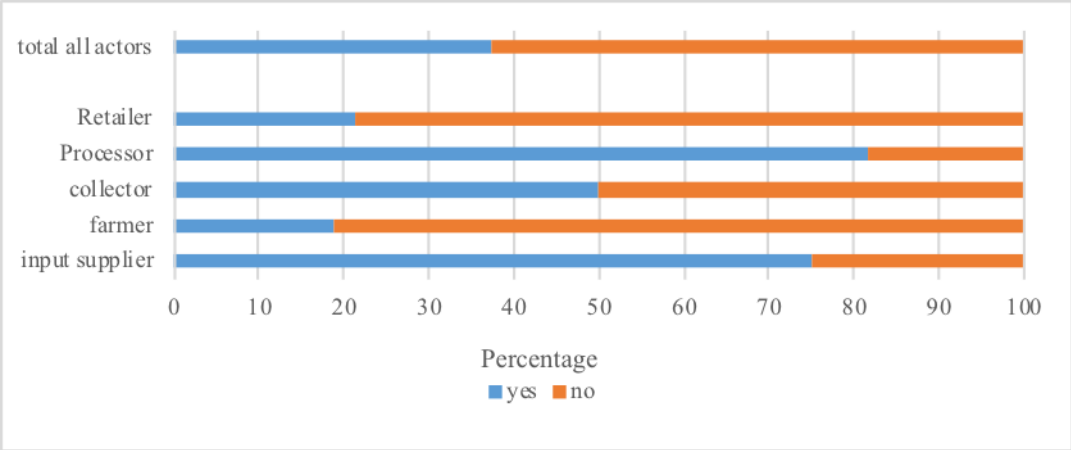

Figure 22. Overview of actors of informal sector that work together with other actors related to their waste. Source: author

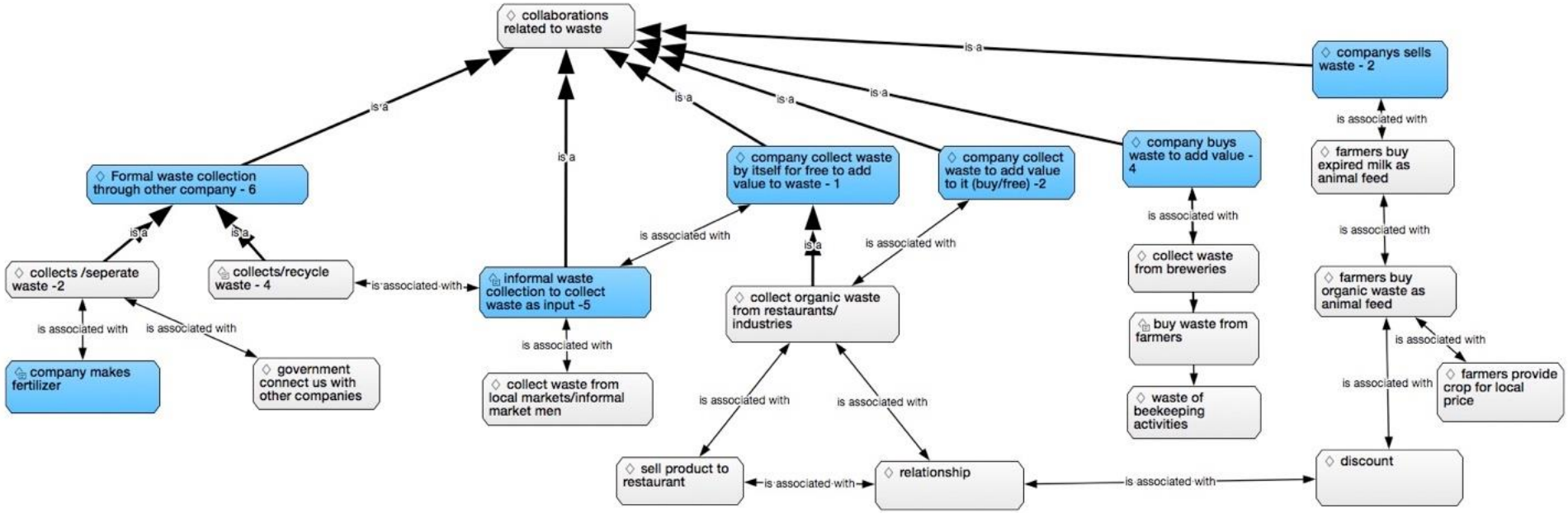

Figure 24. Overview of different types of collaborations of the formal companies that work together with other companies or actors related to waste, recycling or renewable resources. Every relation (colored in blue) is expressed by a number that represent the frequency of the relation. Source: author

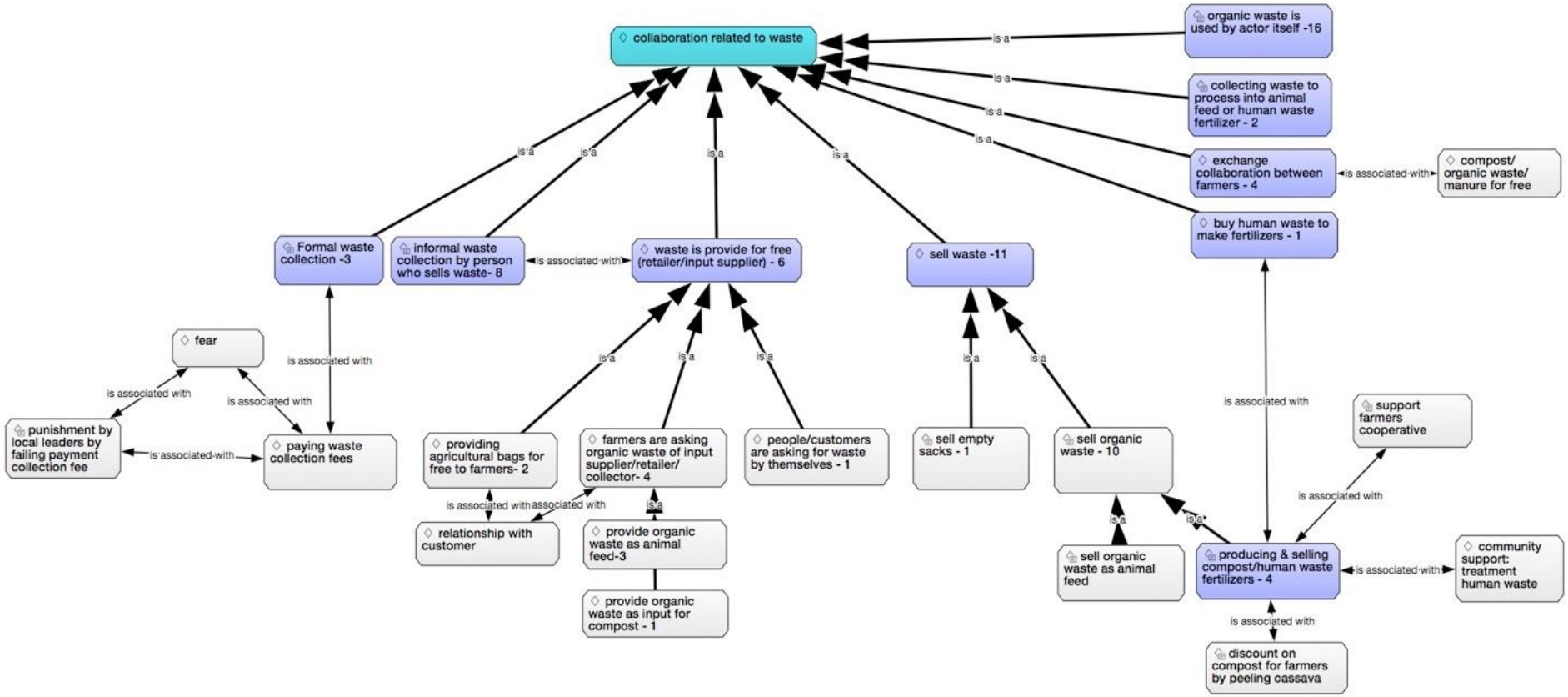

Figure 23. Overview of different collaborations between actors related to their waste for the 'informal sector'. Every relation (colored in purple) is expressed by a number that represent the frequency of the relation. Source: author

4.2.2 Recycling and re-use of resources

About 73 percent of the respondents in the 'formal sector' indicated implementation of recycling practices, which is significantly higher than the 'informal sector' (30 percent of the respondents) (figure 25).

The respondents of the 'formal sector' that stated were engaging in recycling practices by recycling plastics, papers, glass bottles, water, agricultural or plastic bags or organic waste. For instance, plastics are recycled by growing mushrooms into plastic bags and by the return of these plastic bags to the supplier. Other forms of recycling include the informal collection of glass bottles of hotels, shops, airport for the package material for products or the utilization of organic waste. Organic waste is used to grow black soldier flies (insects) on organic waste as animal feed or into compost or organic fertilizers. Water is recycled through a wastewater plant (paragraph 4.2.1) or modern farming systems such as aquaponics, hydroponics or vertical farming.

> "We buy plastic bags from a supplier. We use the bags to grow mushrooms and after utilization we return the bag back to the recycler/supplier. The supplier cleans it and we can use it again. The blue package material of the mushrooms is recycled by the customer who buys the mushrooms. If we would collect it for recycling we have issue hygiene/cleaning issues in order to recycle the package material". - Mushroom grower

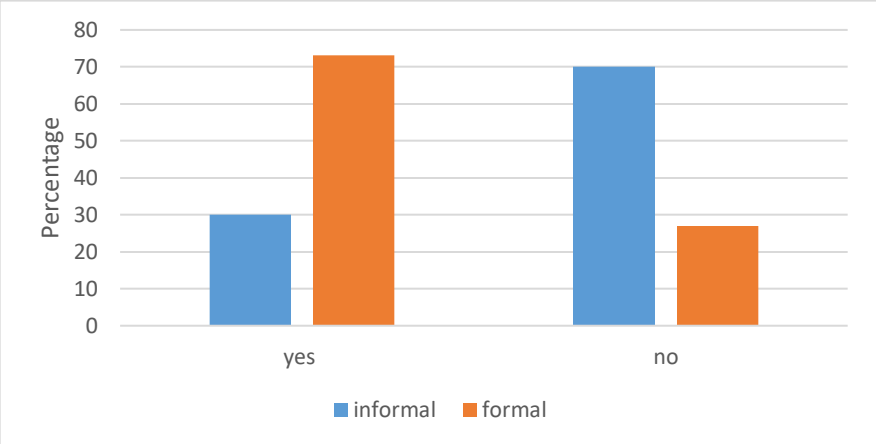

Figure 25. Overview of respondents that apply recycling practices in the 'informal' and 'formal sector'. Source: author

About 30 percent of all respondents in the 'informal sector' indicated applying recycling practices, which are mostly input suppliers, farmers and retailers (figure 26). This research has compared the results about recycling practices between the answers of the respondents and their actually observed recycling practices (figure 27). It is observed that all actors are implementing

more recycling practices than it is indicated by the actors itself. For instance, 29 percent of the input suppliers answered in the interviews that they implement recycling practices, however, it is observed that 100 percent of the observed input suppliers implement recycling practices (figure 27). An exception can be made for the collectors, since very limited observations could be conducted due practical reasons that are further discussed in the discussion and conclusion. It is important to note that not all interviewed respondents were observed, due to practical reasons. Therefore, the percentage of figure 27 is only calculated over the respondents that are observed and interviewed.

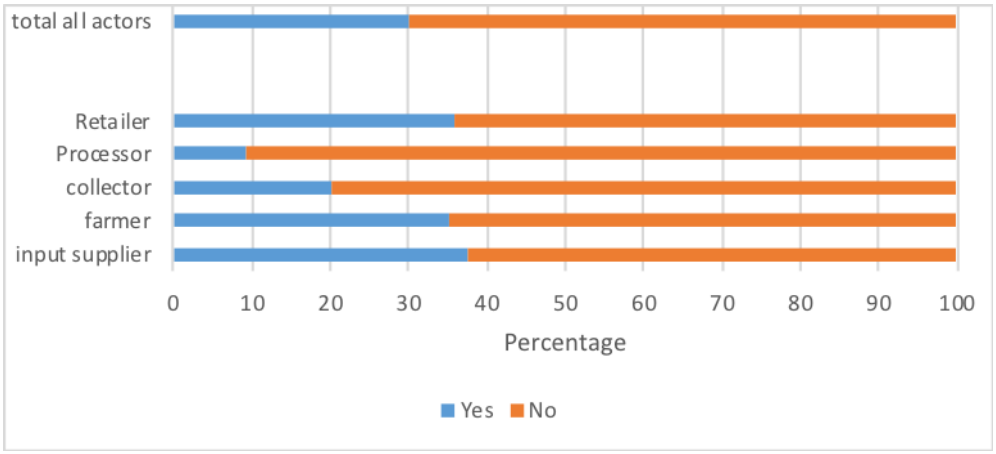

Figure 26 Overview of recycling activities per actor indicated by the respondents of the 'informal sector'. Source: author

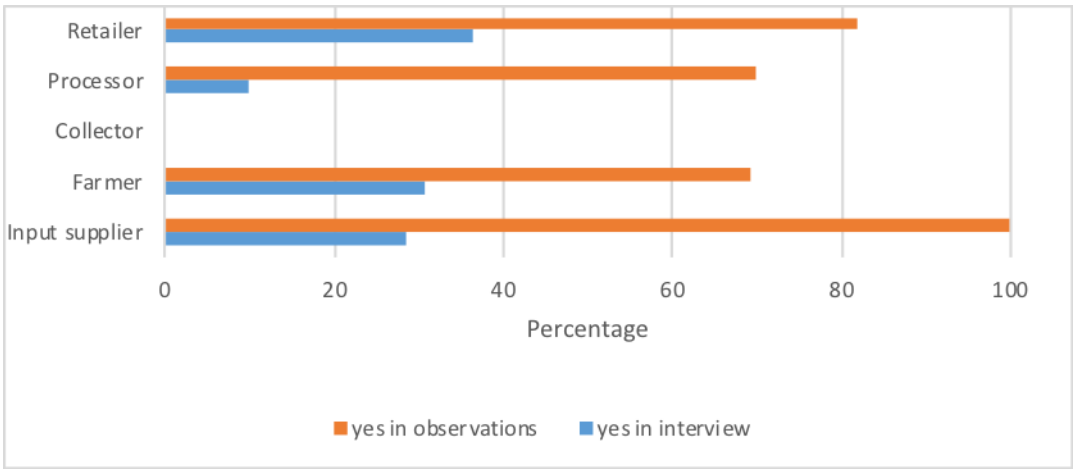

Figure 27. Difference of recycling activities in percentage that is indicated by the interviews and by the observation of each observed actor. Source: author

Input suppliers indicated that they recycle empty agricultural bags to avoid water from streaming into their house during the rainy season or recycle the tin packaging of seeds that is provided for free. The input suppliers provide old papers for free to customers and some input

suppliers indicated that they use old papers to make paper bags, which was also observed (figure 28). Furthermore, it is seen that input suppliers recycle old jerry cans into a scoop to move products such as organic fertilizers, etc. into bags (figure 29). Agricultural bags are used for the storage of products or to cover and used plastic containers are utilized for the storage of products.

> "I use agricultural bags to avoid that water streams into my own house. I put soil in the empty bags".
>
> "The tin packaging of seeds is provided for free to people who recycle. The people who are collecting are not ones that are recycling. It is recycled by persons for whatever they want to do with it". – Input supplier

Farmers have indicated to recycle old agricultural bags into handmade baskets, old jerry cans are used to grow plants, to soak cassava or are utilized to transport water/seeds from one place to another place. Agricultural bags are also used as storage of the harvest, which is also observed in the field. It is also seen that agricultural bags are utilized to dry cassava or other crops, to stop water of streaming into houses, stabilizing the soil, or to create a shadow for the shelters of the cows.

> "I use mosquito nets and basins to construct a kitchen garden".

Only one processor stated to implement recycling by cutting jerry cans into a scoop to move flour from one place to another place, which is also seen in the field (figure 29). Furthermore, it is observed that agricultural bags are recycled for storage of cassava or to cover the open spaces of the milling facility with agricultural bags. In some cases, the farmer arrived with an agricultural bag with cassava to the processor, the cassava is milled into flour and the bag with the cassava flour returns back to the farmer.

Retailers have indicated to implement recycling by drying cassava and other crops on top of agricultural bags. In addition, it is observed that agricultural bags are utilized for the storage of products such as cassava flour. As indicated by the respondents itself, jerry cans are used to soak cassava or to purchase cooking oil/to fetch water and paper boxes are cut open to pack products for customers. One respondent also answered that she recycles old clothes into kids' clothes, which has less to do with recycling of the retailing activities. Furthermore, it is seen that jerry cans are cut into scoops to transfer products such as cassava flour into other bags in order to sell it to the customer.

Figure 28. An input supplier sells products in a paper bag made from recycled paper. Source: author

Figure 29. Recycled jerry cans are cut into scoops. Source: author

Re-use

Besides recycling the actors can also implement re-use practices. This means that "products or components that are not waste are used again for the same purpose" (Eurostat, 2019, para 1), while the term recycling refers to a "recovery operation whereby waste materials are reprocessed into products, materials or substances whether for original or other purposes" (Eurostat, 2014, para 1).

About 92 percent of the respondents of the 'formal sector' re-use materials and equipment in their business activities (figure 30). This mostly includes the re-use of equipment in the production or processing activities, baskets, packaging boxes for storage, installations (e.g. aquaponics systems, biogas installation systems) and tools. For instance, agricultural bags are bought to grow plants in the bags or the re-use of baskets to collect tea.

> "At large scale equipment is re-used, such as cages for hatching black soldier flies. At small scale we are selling bins for households to grow insects on organic waste as animal feed. These bins are re-used by the households". – black soldier fly farm

In contrast to the 'formal sector', the 'informal' sector uses more simple tools and equipment. For instance, input suppliers implement re-use practices by the re-use of containers for storage, use of baskets to sell/dry of crops, cups that are used to measure/move products such as flour or other crops. Farmers re-use baskets to collect, dry or storage crops, plastic sheets are used to dry cassava and other crops, farming equipment and tools. In some cases, farmers use wooden frames to dry crops. Processors re-use processing equipment to mill cassava and plastic sheets for storage and to dry cassava. A modern processing facility in Kamonyi makes use of wooden frames to dry cassava. On top of the wooden frames plastic and corrugated sheets are used to protect the cassava from rain and humidity. Retailers re-use containers, measurement equipment, plastic sheets to dry crops, baskets to dry or sell crops and sometimes baskets are also used to separate the crops from the waste for instance by peeling beans.

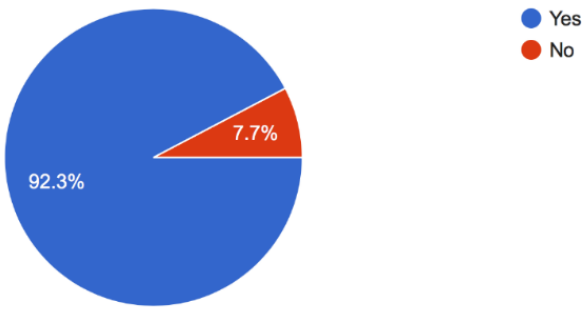

Figure 30. Overview of respondents that re-use materials in the 'formal sector'. Source: author

Figure 31. Re-use of materials to dry cassava by a processing facility. Source: author

Figure 32. Baskets and agricultural bags are re-used. Source: author

4.2.3 Renewable resources

The 'formal sector' uses significant more renewable resources than the 'informal sector', especially since the 'informal sector' use 55 percent firewood (indicated as biomass). About 74 percent of all respondents of the 'informal sector' uses electricity and 55 percent of all actors use biomass (firewood) for cooking purposes at their home (figure 33). Especially farmers use firewood for cooking purposes (65 percent). Only 13.8 percent of all actors use solar energy, which are mostly farmers, retailers, and collectors. The solar lights/panel were also observed in the field. The actors stated to use other types of energy once the energy finished or due to a

power cut by the use of candles and torches. One farmer has indicated that the kids make small solar lights and batteries by collecting materials to light the house.

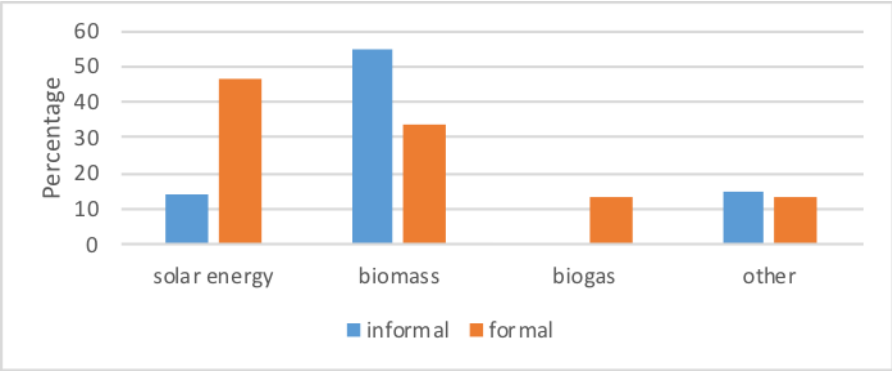

Figure 33. Overview of different types of energy resources that are utilized by the (in) formal sector. Source: author

Almost 54 percent of the respondents of the 'formal sector' apply renewable resources in their business activities. Most of the respondents use solar energy as renewable energy resources. One company stress that a by-product of sugar (bagasse) is used to generate 80 to 90 percent of the energy of the company, while another company stress that solar energy only covers five percent of the required energy. Two companies use renewable resources to improve the relationship between the company and staff by providing staff with solar panels for their home, warm showers for staff generated on solar energy and biogas that is used to cook lunches for staff. One company stress that they do not utilize the renewable resources for their own business, but the respondent's company produce briquettes that can be used by consumers as a renewable resource for energy.

> "The employees are provided with solar panels at the household, which support a good relationship with our employees. Furthermore, biogas is used at the main house for cooking (family house), left over is used for compost". – Organic farm

4.3 Barriers of implementing a circular economy in the agricultural sector in East Africa

This paragraph discusses the different typologies of determinants towards the circular economy, namely technical, financial/market, institutional/regulatory, organizational, social/cultural, environmental and other identified determinants in Rwanda's informal food system and the East African 'formal food system' to establish a circular economy.

Before this paragraph reviews the different barriers in-depth, this study would like to present an overall review of the different barriers between the 'informal' and 'formal agricultural sector'. As shown in figure 35, the 'informal sector' receives significantly less technical, financial, organizational, cultural/social, and policy support than the 'formal sector'. There is a significant difference in support, with only 9 percent of the 'informal sector' receives technical support compared to 65 percent of the 'formal sector'. Similarly, implications for policies apply, since only 6 percent of the 'informal sector' is impacted by policies compared to 54 percent of the 'formal sector'.

In order to calculate the percentages of the different barriers for both respondent groups, the respondents were asked if they receive technical/financial/social-cultural or other support. For instance, the question 'are there any organizations, research/government institutions providing you with new information, training or new technologies (communication, equipment, renewable resources, etc.) to enhance the operations of your company?' is answered with 'yes' the number of respondents that answered 'yes'/'no' are counted. A percentage is calculated over the total informal/formal respondent group (paragraph 4.1) that answered 'yes'. The 'informal sector' also present percentages calculated over the total number of different actors (paragraph 4.1) within the informal sector since every actor has a different function in the value chain.

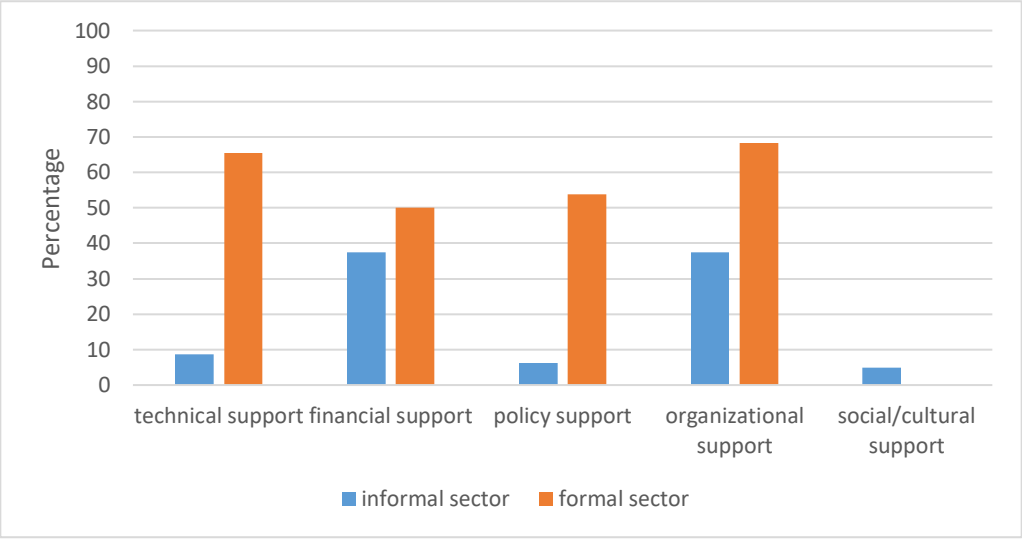

Figure 35. Overview of different types of support between the informal and formal agricultural sector. Source: author

Technical barriers

As stressed earlier, there is a great difference between the 'informal' and 'formal sector' that receives technical support (information, training and new technologies) (figure 35). Only 9 percent of all respondents in the 'informal sector' receive new information, training or technologies to improve their business activities. This is only applicable for input suppliers, farmers and processors (figure 36). In case the respondents receive support of any organization it is mostly about training. One input supplier received training how to use fertilizers by RAB (Rwanda Agriculture Board). Furthermore, one processor receives financial support for a milling machine and repairs, and one processor stated to receive training to increase productivity. A few farmers received training to increase productivity by applying fertilizers and other inputs. One farmer received training about the utilization of human waste as a fertilizer from a non-governmental organization (NGO). However, many farmers stated their lack of knowledge to produce, treat and apply high-quality compost during the interviews. One farmer (who is also a collector) stressed that the current knowledge to make compost is based on traditional knowledge. It is stressed that by the respondents that they need to receive training about making and applying high-quality compost and to add value to waste.

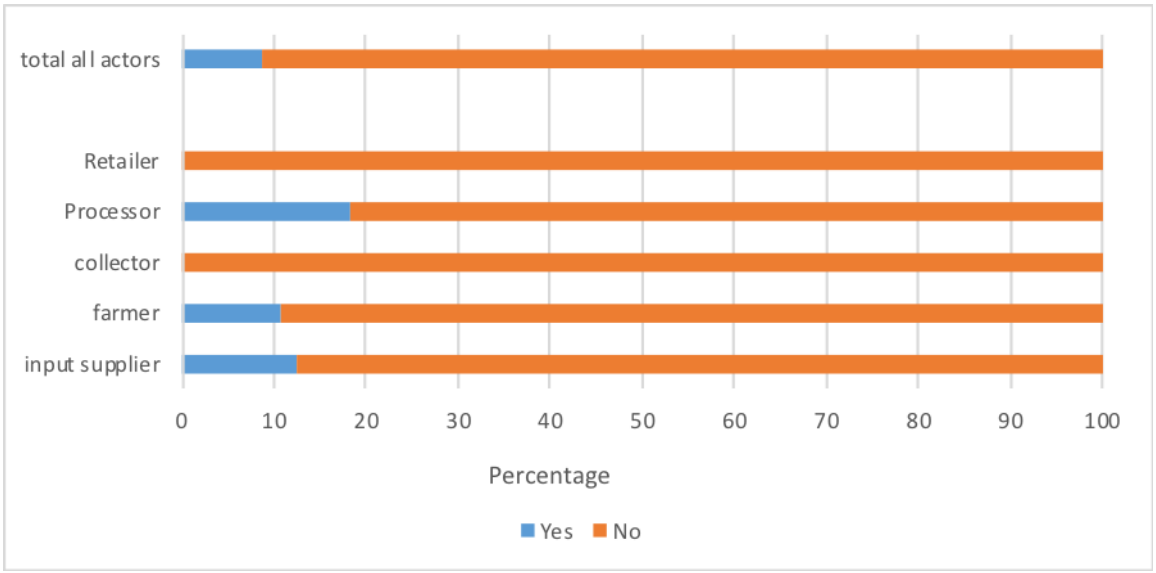

Figure 36. Overview of the actors that are receiving new information, training or technologies to enhance their business activities. Source: author

Another barrier that is noticed is that not all actors in the 'informal sector' understand the 'term' recycling. In many cases, actors do think that they do not implement recycling practices, while it is observed that the actors do implement recycling (figure 27). Many respondents stressed that it was their first time that they are approached to discuss waste and recycling topics. Some actors replied with "you are the first one talking about waste", "waste is useless", "nobody is talking about waste, I am even surprised that you are still talking about waste". Furthermore, it is stated that respondents need equipment and materials to process waste, since there is a lack of equipment to process waste. For instance, a collector stressed that there is a need for clogs, mouth cap, etc. in order to protect herself during processing of human waste.

In contrast, with the 'informal sector' the 'formal sector receives significant more support, since 65 percent of the 'formal' indicated receiving technical support. About 59 percent of the support has been provided by the government followed by the support of non-governmental organization (NGO's) (53 percent) and research institutions (47 percent) (figure 37). As shown in figure 37, each company can receive more than one type of support.

Government support is focused on capacity building and to provide grants through international governments. In Rwanda, the local government also supports youth working in or related to agriculture by sharing information, training and providing an office location for half price rent. NGO's are mostly focused on capacity building through trainings, in one case an NGO provided a grant relevant to waste management. In addition, one company was hired to provide training and demonstrations to farmers through NGO's and is not supported by an NGO itself. Research institutions are focused on research (e.g. value chain development) and by providing trainings. In one case, a company with close relations with a university was hired to train students on how to use a wastewater system as a demonstration. Consultants have provided support to design and improve farms including visits to monitor an installed biogas system.

Companies stated they would like to receive improved education and infrastructure for waste collection and separation. Other respondents in the 'formal sector' stated that they would like to receive technical support through training and working equipment and support in training local staff due to language barriers. Moreover, respondents stress that there is a need for access to relevant waste data and research. For instance, a company that grows black soldier flies as animal feed stressed that there is a need for more research about the upscaling of the business

and the effect of temperature and humidity on the process of breeding maggots. Furthermore, some respondents would like to receive technical and financial partnerships.

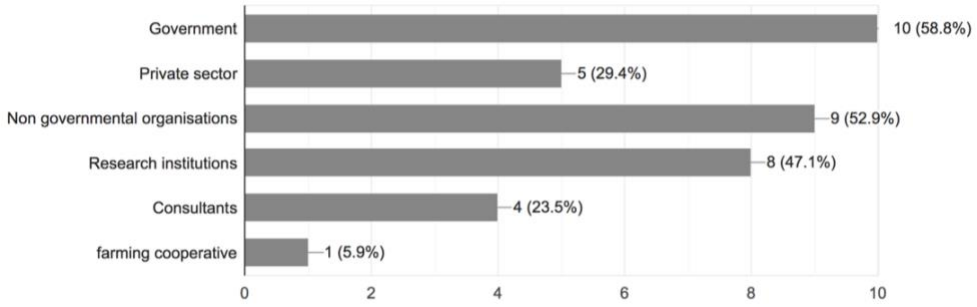

Figure 37. Overview of different types of support that 'formal' companies receive. Source: author

Importance of different technical barriers

To understand how important technical barriers are for 'formal companies' to implement a circular economy model, respondents were asked to rank the importance of different barriers on a Likert scale from 1 to 6. A six (6) indicates that the barrier is the highest important (great barrier), while grade 1 indicates low or not important. The technical barrier 'lack of appropriate technologies to implement a circular economy business model' provides a mixed outcome, since 50 percent of the respondents rank it as totally not important (1) to not important (3) and another 50 percent rank it as important to highly important (figure 38). Some respondents stressed that the companies have technologies but that their company needs improved/more technologies or financial resources to have access to the technologies. However, companies indicate that there is a 'lack of skilled workers, technical support training and knowledge to establish a circular economy model', since 69 percent indicate this as an important to highly important barrier (figure 39). As shown in figure 40, 69 percent indicated that the barrier path dependency in specialized knowledge and technical knowledge as (totally) not important. Respondents stressed that the company was recently started, therefore companies are not too much specialized in certain technologies or knowledge. About 64 percent of all respondents are owner/manager of a company that is younger than five years (paragraph 64).

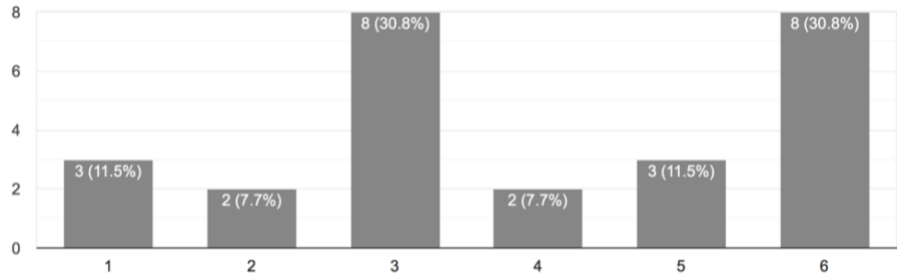

Figure 38. The importance of the technical barrier 'lack of appropriate technologies to establish a circular economy business model. Source: author

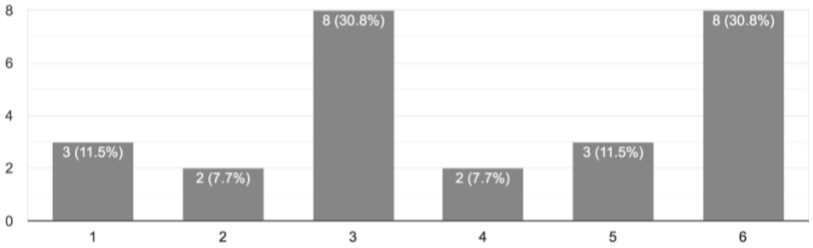

Figure 39. The importance of the technical barrier 'lack of skilled workers, technical support and knowledge to establish a circular business model'. Source: author

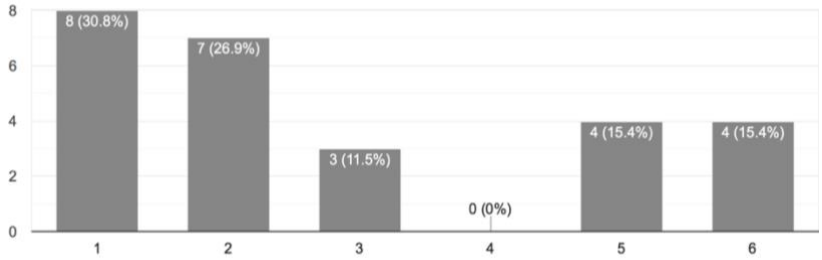

Figure 40. The importance of the technical barrier 'path dependency in specialized knowledge, technological skills and large investments in specialized technologies'. Source: author

Financial/economical barriers

As shown in figure 34, 37.5 percent of all actors of the 'informal sector' received financial support compared to 50 percent of the respondents of the 'formal sector'. In the 'informal sector' most support was focused on input suppliers, retailers and processors with financial resources (figure 41). Financial support is mostly provided through banks, microfinance and some informal farmer cooperatives. The financial support for input suppliers is used to buy fertilizers, inputs, labor and other agricultural activities. Farmers received support for paying labour and inputs through informal farmer cooperation or microfinance. Processors received support informal cooperatives or banks for paying labor, electricity, rent or investment and repairing a milling

machine. Remarkable is that financial support for farmers and collectors is limited, which is also expressed by farmers “I do not receive financial support even my neighbors do not receive financial support”. Furthermore, it is stressed by the actors that the barrier towards the management of waste that the actors provide waste for free, which means that some actors do not receive profit from their waste.

About 50 percent of the respondents of the ‘formal sector’ have confirmed that investors are willing to invest in their business, while another 50 percent confirmed that investors are not willing to invest in their company. Most of the respondents receive financial support through formal institutions (banks, micro-finance), international and local governments (e.g. subsidies and grants), and NGO’s (figure 37). However, two respondents stress that the company is not sure about the commitment of the institutions that showed their interest since the respondents waits for feedback. One respondent received informal support by consultants that provided extra services for free.

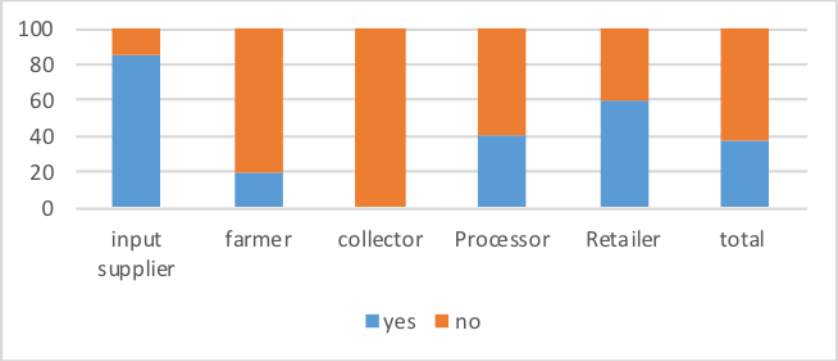

Figure 41. Overview of financial support per actor of the ‘informal sector’. Source: author

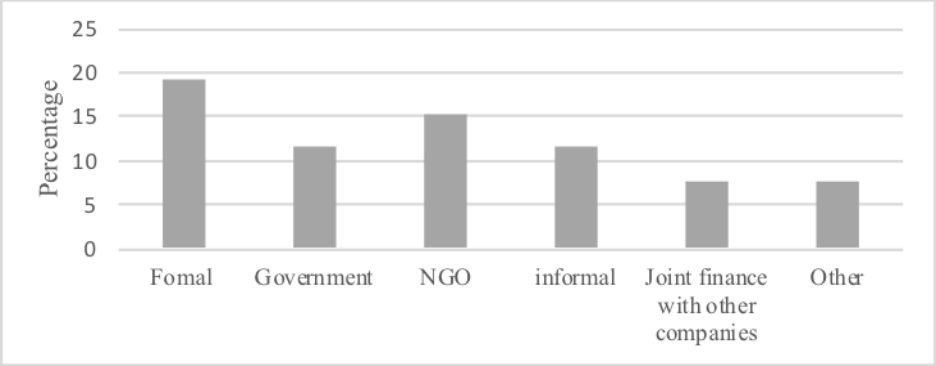

Figure 42. Overview of different institutions that provide financial support to formal companies in East Africa. Source: author

Importance of financial/market barriers

Similar, to the technical barriers, this study seeks to understand how important financial barriers are for companies to implement a circular economy model, respondents are asked to rank the importance of different barriers on Likert scale from 1 (totally not important) to 6 (highly important) (figure 43 and table 13). The financial barrier 'large capital requirements and high initial cost for establishing a circular economy business model' is indicated by 73 percent of the respondents as an important to highly important barrier (figure 44). Some respondents stated that the company does not have the financial resources to invest in additional technologies to make the business more circular or to upscale the business. Other financial/market barriers are not indicated as an important to highly important financial/market barriers, since other barriers are indicated as important for fifty percent or less (figure 43 and table 13). Remarkable is that the financial barrier 'circular business model is not profitable' is indicated by 77 percent of respondents as not important to totally not important to establish a circular economy business model (figure 40).

This means that 77 percent of the respondents consider circular business models as profitable. This is in line with the barrier 'new circular business models that are not proven hamper investment' that is indicated by 62 percent of the respondents as not important to totally not important to establish a circular economy business model. Some of the respondents, stress that it was a barrier in the beginning, but that the use of demonstrations or samples helps to overcome this barrier. Remarkable is that the barrier 'circular economy business models depend on long term investment hampers the shift towards a circular economy business model' is indicated by 65 of the respondents as not to highly not important. It is stressed that the company can hire other companies to collect waste, therefore the company has enough waste. On the other hand, it is also stated that the quantity of organic waste that is used as animal feed differs since the restaurants have more customers at the weekend or that the company does not have the capacity to collect waste from households which results in that the company is dependent on other companies.

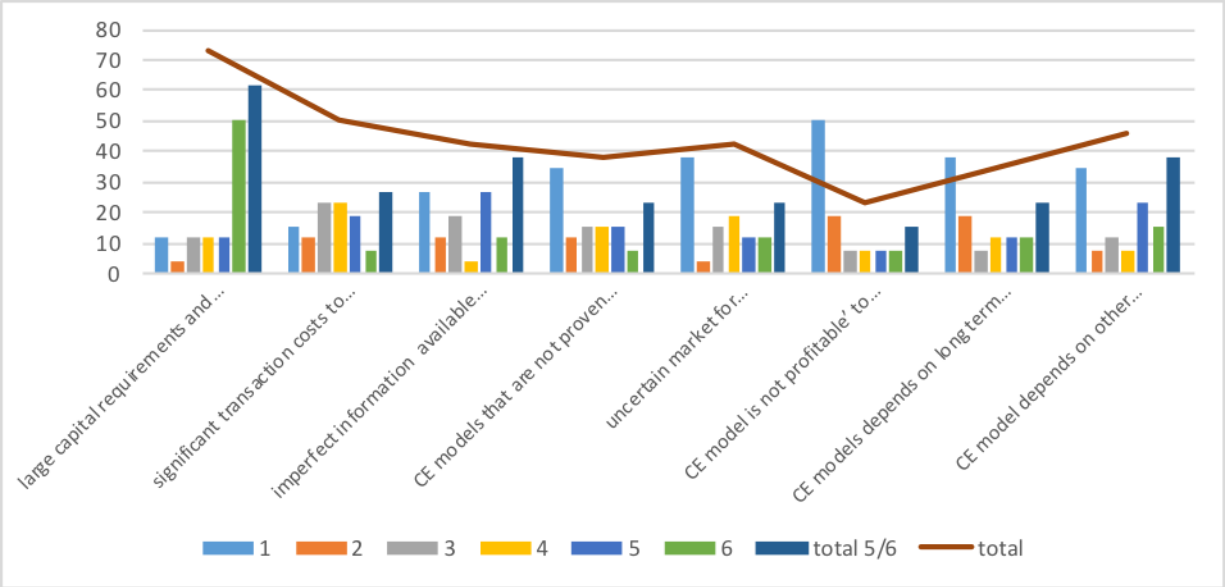

Figure 43. Overview of the importance of different financial/market barriers in percentage Source: author

"Business competitions are like football, you want to win the game (World Cup)". – Free range chicken farm.

Table 13. Overview of the importance of different financial/market barriers in percentage.

	1	**2**	**3**	**4**	**5**	**6**	**total 5/6**	**total**
Large capital requirements and high initial cost to establish CE business model	11.5	3.8	11.5	11.5	11.5	50	61.5	73
Significant transaction costs to establish CE	15.4	11.5	23.1	23.1	19.2	7.7	26.9	50
Imperfect information available about quality of CE products/services for company and customers	26.9	11.5	19.2	3.8	26.9	11.5	38.4	42.2
CE models that are not proven hamper investment for CE products	34.6	11.5	15.4	15.4	15.4	7.7	23.1	38.5
Uncertain market for products/services with CE model	38.5	3.8	15.4	19.2	11.5	11.5	23	42.2
CE model is not profitable	50	19.2	7.7	7.7	7.7	7.7	15.4	23.1
CE models depends on long term investment hampers the shift towards CE	38.5	19.2	7.7	11.5	11.5	11.5	23	34.5
CE model depends on other business in one integrated value chain'	34.6	7.7	11.5	7.7	23.1	15.4	38.5	46.2

Source: author

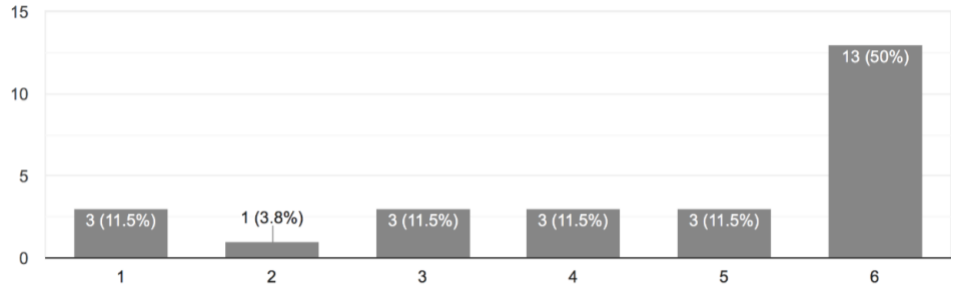

Figure 44. The importance of the financial barrier 'large capital requirements and high initial cost for establishing a circular economy business model'. Source: author

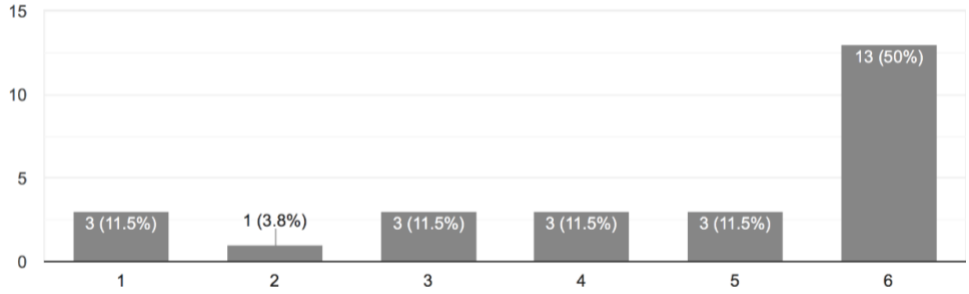

Figure 45. Importance of the market barrier 'circular business model is not profitable' to establish a circular business model. Source: author

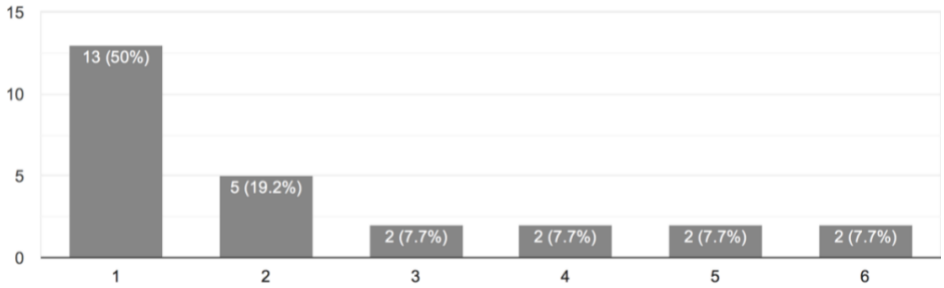

Figure 46. Importance of the market barrier 'circular business model is not profitable' to establish a circular model. Source: author

Organizational barriers

As mentioned earlier, 81 percent of the 'formal companies' work together related to their waste compared to 37.5 percent of the respondents of the 'informal sector', which is a significant difference. Only 4 percent of the respondents report receiving institutional support to interconnect with actors for circular economy practices (figure 23), which are limited to processors and retailers. For example, processors receive support from a private company that purchases organic waste as animal feed. Two retailers received the support of the local government. One respondent is informed by the local government to keep the shop clean, which is an incentive to do something actively with the (organic) waste. Furthermore, another retailer is

encouraged to pay collection fees to the company that collects waste to avoid punishment by dismissing the payment.

In contrast, 68 percent of the respondents of the 'formal sector' received institutional support in order to interconnect with other actors related to their waste, recycling or renewable resource. This are mostly NGO's (43 percent) and government institutions (29 percent) (figure 54). Governmental authorities and NGO's play a facilitation role by the interconnection of companies with other relevant actors/companies. For instance, a respondent who produces compost in Rwanda receives the support of the district by connecting the company with other companies (e.g. waste collection companies) and shares the different responsibilities.

Two respondents in Rwanda stresses that waste collection fees of private companies that collect waste are a challenge, since the company does not collect the waste when the company fails to pay the not negotiable fees. Furthermore, it is stressed by another respondent that there is no economic incentive to recycle plastics since the company does not benefit from the recycling. In addition, the quality, waste separation and quantity of organic waste is stated as a barrier. For instance, one respondent with a black soldier fly farm stressed that the company faces challenges to receive high *quantities* of organic waste, since the supplier of organic waste does not have available waste when the supplier is not producing. In addition, the respondent stresses the lack of correctly applicable technologies. It was also stressed by two other respondents with a black soldier fly farm that the quality of organic waste difference and that the lack of waste separation by the source results into additional staff costs to sort the waste. Furthermore, a respondent, who is growing mushrooms on compost, stressed that logistics of waste collection to make compost is a challenge. The respondent's company needed to coordinate the waste collection of the farmers and the belonging fees by the company itself, which is stressed as a challenging task.

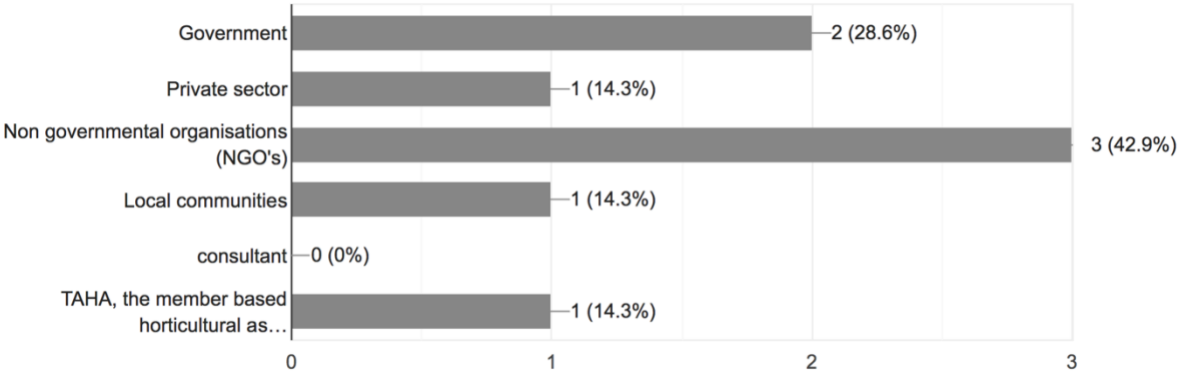

Figure 47. Overview of actors that receive support of institutions to establish collaborations with other actors related to their waste. Source: author

The respondents stated different barriers around informal waste collection. One respondent collects waste informally (e.g. glass bottles as package material) from restaurants and hotels, which results in security issues since there is no agreement with the owners. Furthermore, one company was not happy with the informal profile of the person who was in charge of waste collection, which results that the company temporarily stopping waste collection. One respondent, that created a local market for cocopeat, or waste from coconuts, in Tanzania, stated that is not possible for foreign investors to work together with companies that are not registered by BRELA, the formal registrar of companies in the country. In this case the company needed to exclude working with informal companies, since this result in non-compliance and risk of fines.

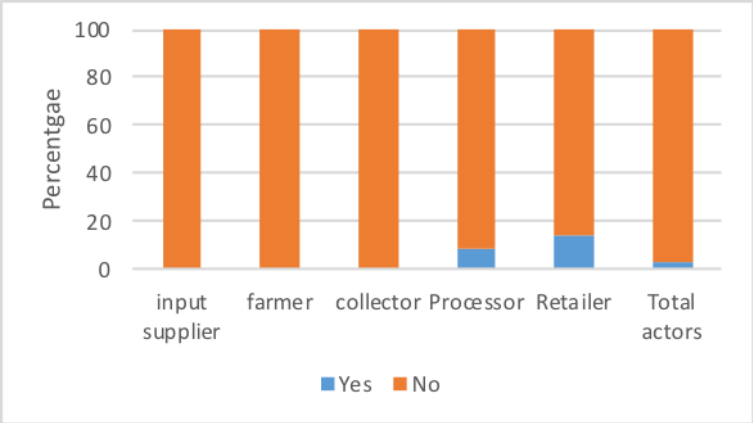

Figure 48. Overview of different types of institutions that provide support to interconnect companies with other actors to work together related to their waste, recycling or renewable resources. Source: author

> "Sometimes there is no waste of local breweries because they did not produce beers. It also a challenge to work with other resources, such as pineapple peels, we do not have the right technology to process the waste. This is not good for our black soldier farm".

Importance of organization barriers

Similar to the previous barriers, this study would like to understand how important organizational barriers are for companies to implement a circular economy model. About 69 percent of the respondents stated that 'the different lifecycles of products and inputs e.g. the availability organic waste of the other actors/companies as input to make compost to establish a circular economy model' were totally not to not important to establish a circular economy model (figure 49). Respondents stressed that their company always has access to organic waste or access different sources of organic waste, therefore it was not a barrier for them.

However, respondents stressed that improved waste collection and separation would enhance their business. This is also shown in figure 46, about 81 percent of the respondents stress that the ‘lack of waste collection infrastructure’ is an important to highly important barrier for circular companies. Since the government has an interconnecting role through collaboration with circular companies/waste collection companies to establish waste management infrastructure (which is indicated by the respondents), the barrier ‘lack of a waste collection infrastructure’ can be considered as an organizational barrier.

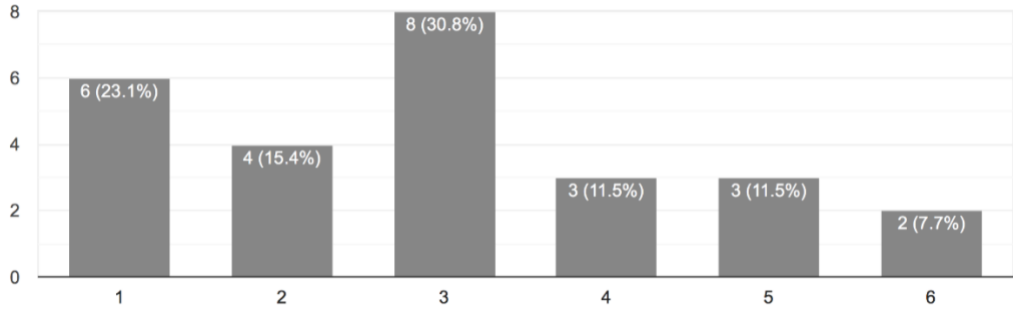

Figure 49. The importance of the barrier ‘the different lifecycles of products and inputs e.g. the availability organic waste of the other actors/companies as input to make compost to establish a circular economy model’. Source: author

Policy and regulatory barriers

As shown in figure 34, 54 percent of the formal companies are impacted by policies and regulations related to waste, although only 6 percent of the respondents of the ‘informal sector’ are impacted by laws/policies or regulations that are related to waste, recycling or renewable energy. The actors of the ‘informal sector’ that are impacted by these laws and regulations are retailers, processors and farmers (figure 50). Retailers are impacted by the advice to clean the shop by clearing the waste or by paying waste collection fees. It is stressed that it is a challenge to comply with payment of the waste collection fees. In some cases, retailers even stressed that they are being reported by the local leaders in case they fail to pay the collection fees. Consequently, the retailer is punished by local leaders, for instance by damage the public image of the retailer. In another case, the retailer stated that there a company will collect the waste in the neighborhood, however it would be enforced to provide waste and pay the collection fee. The respondent stated that some neighbors would like to use the organic waste for their own garden or farm, rather than paying a collection fee for their waste. One processor is impacted by policies and laws related to waste indirectly by policies of the government to provide high-quality flour and to reduce food lost by bad quality of cassava. One farmer stressed that every household is advised by the government to have a decomposing pit for waste. Some farmers stressed that they are impacted by

policies, however these policies are focused to increase the productivity. One input supplier makes the next statement in regards of policies:

> "Nobody can say anything, if I dump my waste". – Input supplier

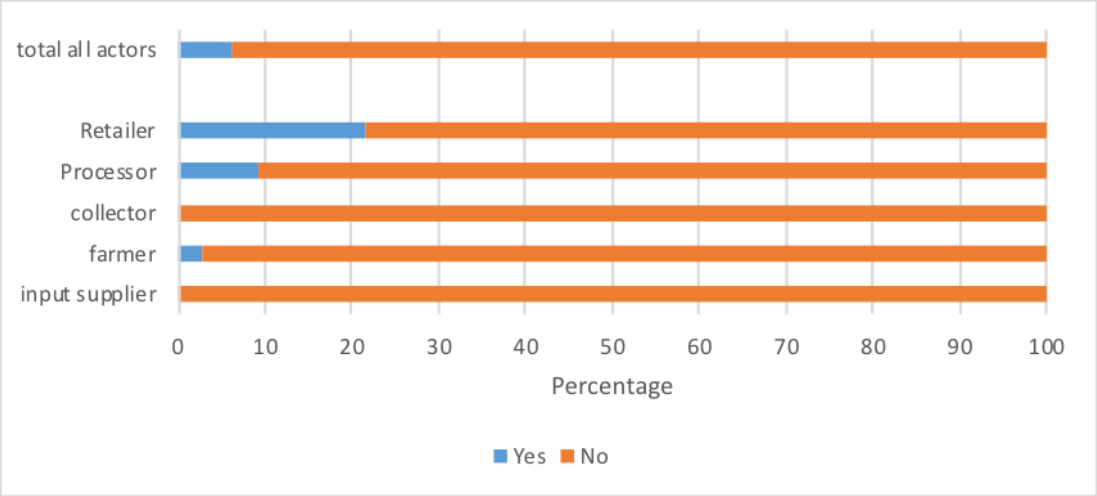

Figure 50. Overview of actors in the 'informal sector' that are impacted by laws/policies or regulations related to waste, recycling or renewable energy. Source: author

However, the 'formal sector' is significantly more impacted by laws, regulations and policies that are related to waste, recycling or renewable resources. In Rwanda, respondents of the 'formal sector' are affected by the ban of single-use plastics. For instance, one respondent only receives a one-year permission to grow mushrooms in plastic bags which hinders the company in making long term investments, while another respondent needs to find solutions for plastic bottles since there are no proper recycling facilities in place yet. Furthermore, it is stated that restaurants need to separate their waste, however waste collection is done through private companies that mix all the separated waste in the truck. On top of that, it was stressed by a respondent that produces compost from the dump side that Rwanda Environmental Management Authority (REMA) provides policies on how to manage waste. In addition, the respondent stresses that REMA advised the company how to work together with the suggested companies by REMA. Another respondent that also produces compost stressed that there are regulations in place that support the company's operations.

The effects of policies are not only seen in Rwanda, but also in Tanzania and Kenya. A respondent located in Tanzania is affected by the environmental department of the government

that informs to improve their business in order to receive a certificate by conducting an environmental assessment. However, once the respondent was finished with the assessment, the government could not assist the company due to the lack of knowledge. Another respondent had installed an incinerator for waste management of the company, however the Tanzanian authorities stipulated that the municipality should collect the waste which resulted that waste of company is dumped at landfills. In Kenya, it is stated by one respondent that the company needs to follow NEMA (National Environmental Management Authority) and other national waste management regulations. Following that, one respondent of a company that produces organic fertilizers stressed that the company is affected by an introduced government regulation that states that livestock manure should be burned and cannot be utilized as an input of fertilizers.

The 'formal sector' has been approached to provide feedback towards policies and regulations related to waste (54 percent), although the 'informal sector' is mostly not included (only 4 percent). The 'formal sector' has been included through face to face meetings (75 percent), stakeholder meetings (50 percent) and by communication through phone/email (33 percent) (figure 53). A few respondents in Rwanda are able to provide their inputs in order to improve guidelines or are actively involved develop standards and quality controls. One Kenyan company stressed that the governments sometimes comes to talk, but that real problems are not solved.

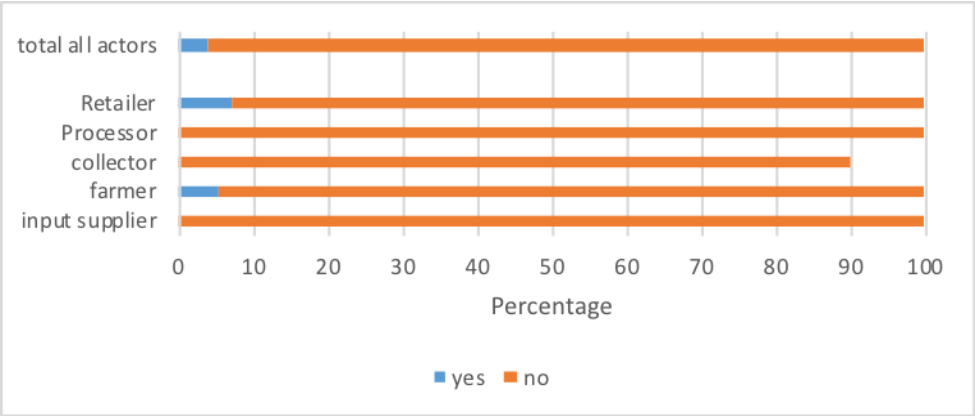

Figure 51. Overview of actors of the 'informal' sector that are approached to provide inputs for laws/policies or regulations related to waste, recycling or renewable energy. Source: author

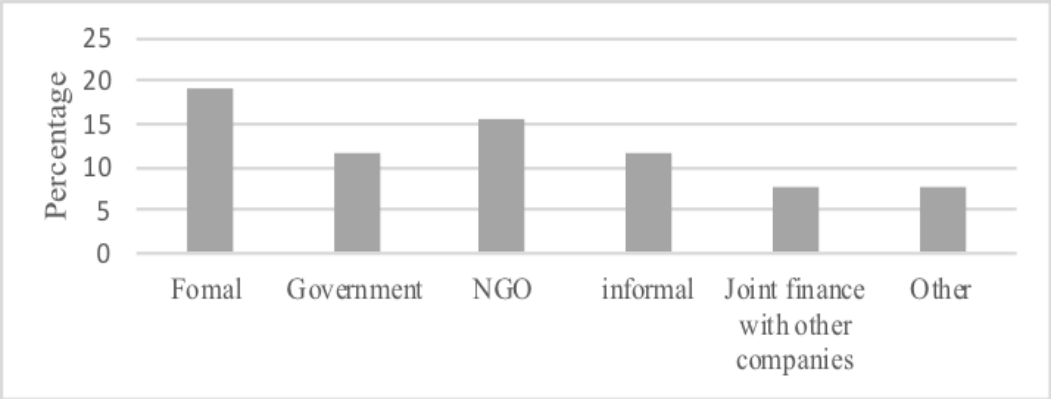

Figure 52. Overview of different institutions that provide financial support to formal companies in East Africa. Source: author

Importance of regulatory/institutional barriers

Similar to the technical barriers, this study would like to understand how important institutional/regulatory barriers are for companies to implement a circular economy model (figure 53 and table 14). About 58 percent of all respondents consider the barrier 'lack of adequate defined policy framework with clearly defined targets, objectives and incentives in policies to establish circular economy business model' as a totally not important to not important barrier (figure 54). Companies stressed that it takes time to establish policies in East African countries, policies are there but that they require improvements. Some respondents stressed that initiatives should come from the companies since governments did not develop proper ways to implement policies. However, the barrier 'implementation and enforcement failures of policies related to waste, recycling and renewable resources' was considered as an important to highly important barrier by 65 percent of the respondents (figure 55). Enforcement failures that stressed by the respondents include the lack of separation of waste and that restaurants in Rwanda needs to sort out waste, however during the pick-up of waste, everything get mixed by the private collection companies.

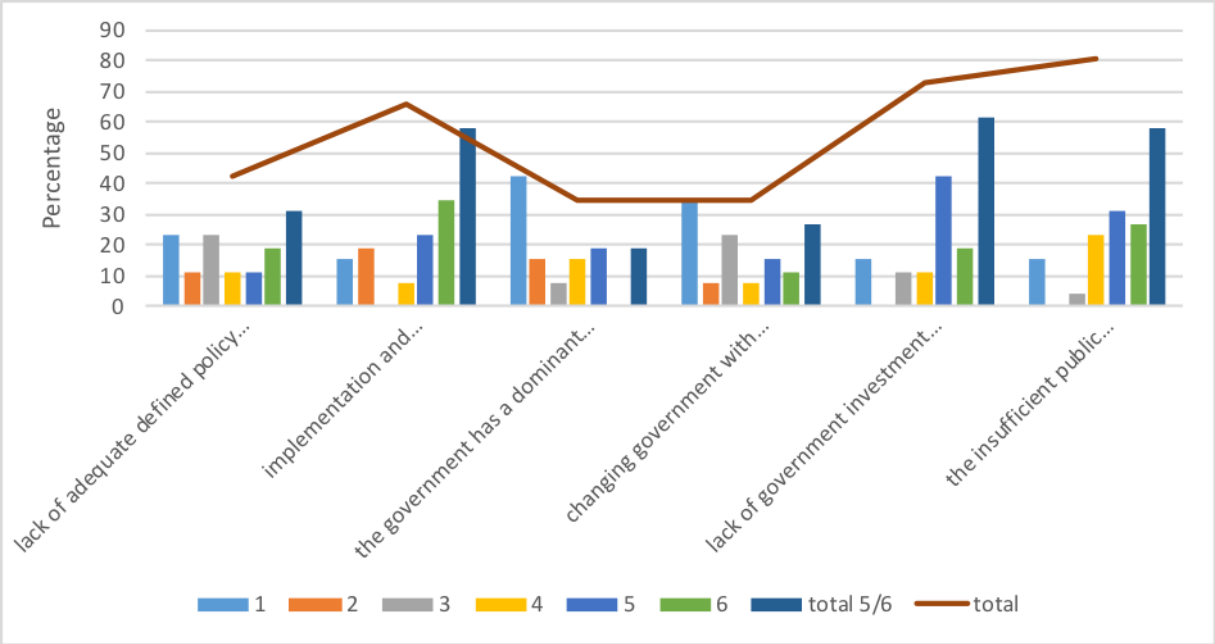

Figure 53. Overview of importance of different institutional and regulatory barriers to establish circular economy. Source: author

Table 14. Overview of the importance of different institutional and regulatory barriers to establish circular economy.

	1	**2**	**3**	**4**	**5**	**6**	**total 5/6**	**total**
Lack of adequate defined policy framework with clear defined targets, objectives and incentives in policies to establish CE business model	23.1	11.5	23.1	11.5	11.5	19.2	30.7	42.2
Implementation and enforcement failures of policies related to waste, recycling and renewable resources'	15.4	19.2	0	7.7	23.1	34.6	57.7	65.4
The government has a dominant discourse on recycling and is not focused on other regulations towards waste, reuse of materials and renewable resources'	42.3	15.4	7.7	15.4	19.2	0	19.2	34.6
Changing government with changing policies'	34.6	7.7	23.1	7.7	15.4	11.5	26.9	34.6
Lack of government investment to establish a circular economy'	15.4	0	11.5	11.5	42.3	19.2	61.5	73
The insufficient public good/infrastructure e.g. there is no formal infrastructure for waste collection/recycling	15.4	0	3.8	23.1	30.8	26.9	57.7	80.8

Source: author

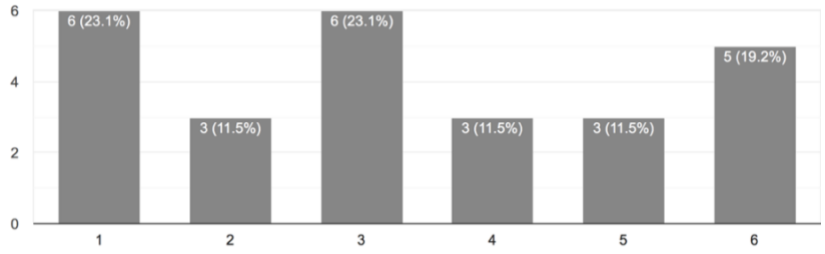

Figure 54. The importance of the barrier 'lack of adequate defined policy framework with clearly defined targets, objectives and incentives in policies to establish circular economy business model'. Source: author

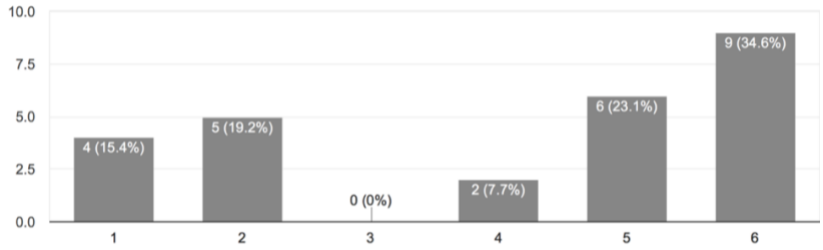

Figure 55. The importance of the barrier 'implementation and enforcement failures of policies related to waste, recycling and renewable resources'. Source: author

Other barriers that are indicated as high include 'the government has a lack of investment capital/willing to establish a circular economy' (total of 73 percent) and 'the insufficient public good/infrastructure e.g. there is no formal infrastructure for waste collection/recycling' (total of 81 percent) (figure 56 and 57). Some respondents stressed that the lack of waste separation at the sources is the biggest problem, since all waste get mixed in the current infrastructure. It suggested by a respondent that the government of Rwanda could establish transfer stations for waste collection and to sort out the waste for households, while the private sector could add value to it. In Rwanda some respondents stressed that there is investment and willingness by the government to invest in circular activities by the government, although there is a lack of awareness for who to contact within the government and the scope of efforts of the private sector. However, others stressed that there is a great need for large efforts in investment from the governments. Other barriers stressed as not important (table 14). It is noticeable that many respondents stressed that the barrier 'changing government with changing policies' is not seen as a current high barrier (total percent of 65) since the shifts in power are not likely to happen at this moment (figure 53 and table 14).

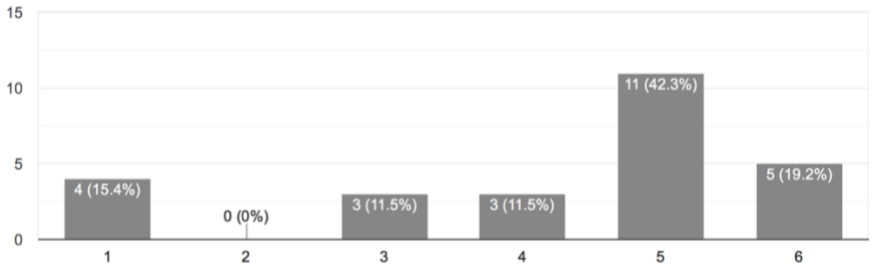

Figure 56. The importance of the barrier 'lack of government investment to establish a circular economy'. Source: author

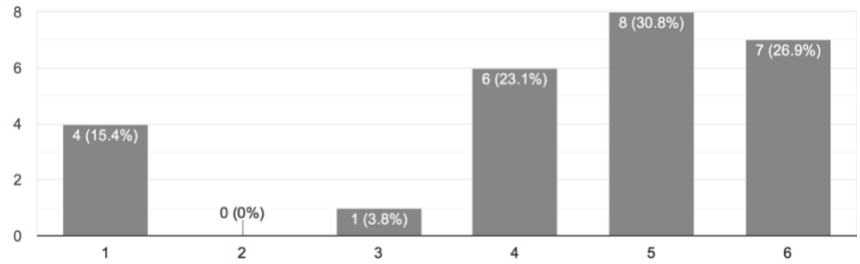

Figure 57. The importance of the barrier 'the insufficient public good/infrastructure e.g. there is no formal infrastructure for waste collection/recycling' to establish a circular economy. Source: author

Social/cultural

Besides regulatory barriers, there are also social-cultural barriers that hamper the development towards circular food systems. The social-cultural aspects are measured in different ways since the 'informal sector' in rural areas is much more actively involved in community activities, which is less applicable for the 'formal sector'. Therefore, it is more complicated to compare the results between the 'informal sector' and 'formal sector'.

Although, it can be stressed that only 5 percent of all respondents of the 'informal sector' confirmed that there are community activities in Kamonyi are related to waste, recycling or renewable and impact the business activities of the respondents. This is only applicable for some retailers, collectors and farmers (figure 58). One farmer and one retailer confirmed that there are sometimes activities in the community to collect plastics and to gather plastics together. One collector confirmed that there are community activities about how to treat human waste into fertilizers. One retailer confirmed that there are Umuganda, or monthly mandated community work, activities for the separation of waste in order to inform the people of the village how to separate waste.

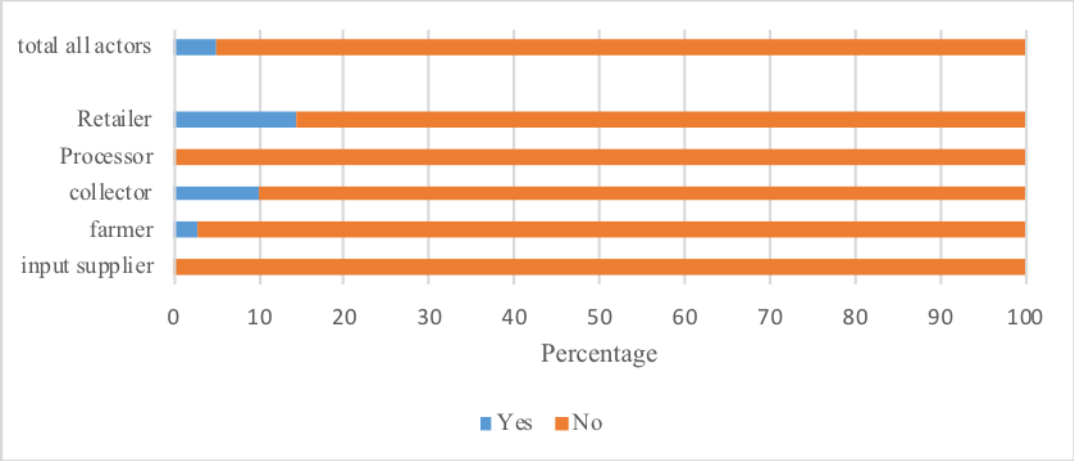

Figure 58. Overview of implemented community activities related to waste, recycling or renewable energy that impact business activities of the different actors. Source: author

> "There are Umuganda activities in our community about how to treat human waste into fertilizers". – collector in Kamonyi, Rwanda

The difference between the social/cultural differences between the two groups can also be seen in the difference in the answers of the question 'what keeps your customers committed to your products?' The 'informal sector' is mostly focused on price and product performance. On top of that, 14 percent of the 'informal sector' produce only for own consumption, which is 30 percent of the farmers. In contrast, the 'formal sector' produces new products that are not/very limited on the East African market (e.g. the production of animal feed with black soldier flies, organic fertilizers, mushrooms) or products that are environmental/community-friendly (e.g. community production around the tea production or products from organic farms).

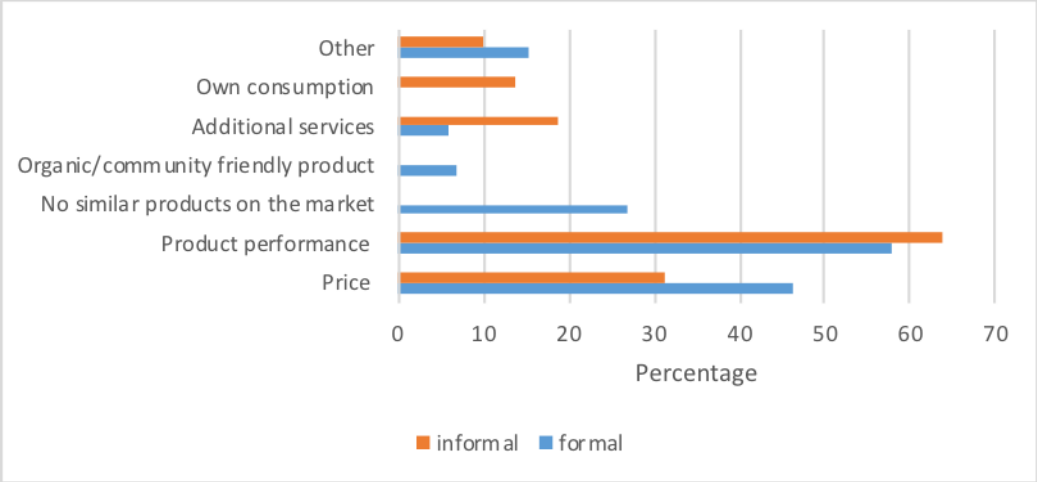

Figure 59. Overview of the differences between the informal and formal sector in regards to their production target. Source: author

Consequently, the 'formal sector' also reported facing different social/cultural barriers towards their products. About 38.5 percent of the respondents face customer behavior challenges towards selling their products to customers, which are mostly issues with the social acceptance of their product (19 percent), environmental literacy (knowledge/awareness of customers) (15 percent) and other (figure 60). An example of social acceptance barriers that were stressed by respondents is that customers are not aware of the fact that inorganic fertilizers do not work immediately compared to inorganic fertilizers. Therefore, customers need to understand the working of the product before they are willing to accept the product. Other social/cultural barriers that were stressed include the lack of customer understanding about the production costs of locally produced rice, lack of understanding about modern horticulture and the use of organic inputs to produce crops. As shown in figure 60, respondents could select more than one barrier.

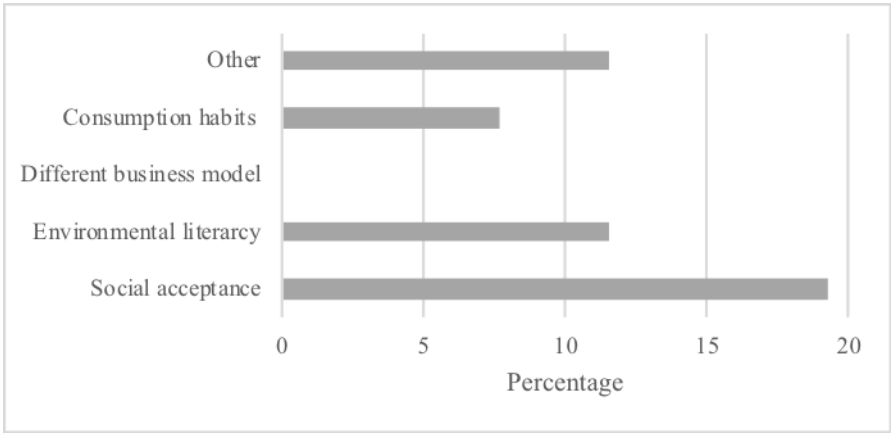

Figure 60. Overview of different types of social/cultural barriers towards circular economy products. Source: author

Importance of social/cultural barriers

Similar to the previous barriers, this study would like to understand how important social and cultural barriers are for companies to implement a circular economy model. The barrier 'customers are not used to products/services with a circular business model due to routines and limited environmental awareness and education' hampers the transition towards a circular economy provides a somehow mixed outcome. About 54 of the respondents stated that it is not important to – totally not important, while 46 percent consider it as an important to highly important (figure 61). One respondent stressed that it is important for customer have a better understanding, since customers need to have a backup. About 77 percent of the respondents

indicated that ‘an economy based on hyper-consumption toward products’ is a highly not to not important barrier to establish a circular business model in agriculture (figure 62).

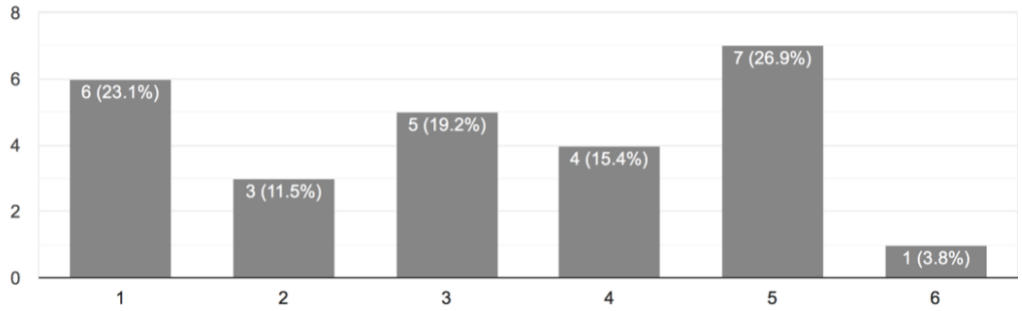

Figure 61. The importance of the barrier ‘customers are not used to products/services with circular business model due to routines and limited environmental awareness and education’ to establish a circular business model. Source: author

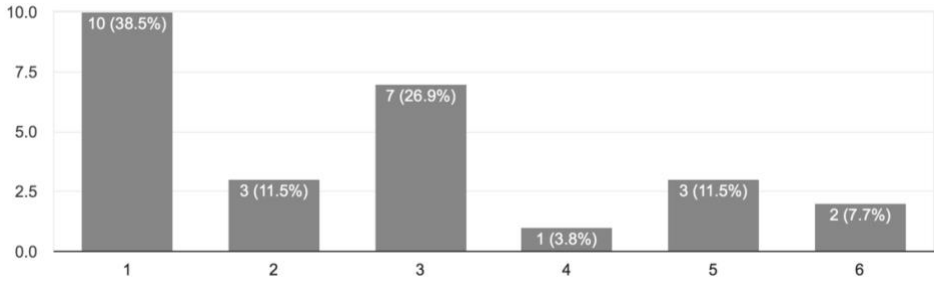

Figure 62. The importance of the barrier ‘an economy that is based on hyper-consumption’ to establish a circular business model. Source: author

Other barriers

During the interviews other implementation barriers were also identified by the respondents of the ‘informal’ and ‘formal agricultural sector’. First of all, there are similar barriers that are stressed by the ‘formal’ and ‘informal sector’. Especially waste collection and separation stressed as an important barrier. This includes the availability of high quantities of organic waste and waste separation at the source to avoid different types of waste from being mixed. In the ‘formal sector’ it was stressed by some respondents that the companies do not always have access to enough quantities or qualities of waste. Although, some collectors and processors in the ‘informal sector’ stated that there is not always a need for organic waste as animal feed, since there is enough animal feed during the rainy season due to the high production rates of farmers. This can be qualified as an environmental barrier. In line with that, some farmers stressed that

there is no organic waste if there is no harvest, which can be identified as an environmental barrier since the quantity of waste differs during the seasons.

> "In raining season there is no demand for organic waste for animals, there is enough animal feed available" – collector.

Furthermore, a collector in the 'informal sector' stated that there is no separation of urine and feces by collection human waste to process it into two different human waste fertilizers (urine and faces). In addition, it is stressed by a collector of the 'informal sector' that time of the treatment of human waste before it can be used as human waste fertilizers is a barrier. This can be qualified as a waste separation barrier.

> "The mixture of human waste from toilet does not separate of urine and faces, while urine and faces can be used as two different types of human waste fertilizers. The challenge of mixture is that it takes long before it can be used" - collector.

Another waste collection barrier that is stressed by some respondents of the 'informal sector' is the quantity of organic waste. The flexible quantities of (organic) waste can be identified as a barrier, since some input suppliers and retailers stressed that the quantity of organic waste is less, while other retailers stressed that there are high quantities of organic waste. Others stress that the demand for animal feed is higher than the availability of organic waste, while others stress that the demand for organic waste as animal feed is too low. This can be qualified as a market information barrier. In addition, the transport of waste is stressed as a barrier. For instance, the transport of manure as fertilizer is heavy, which means that it is a challenge to transport waste. This can be qualified as a transport barrier.

> "I first feed organic waste to animals, then manure is wet (fertilizer). Therefore, it is difficult to transport the waste. I need to buy a wheelbarrow".

The 'formal sector' also stressed other barriers that are not mentioned by the 'informal sector'. Four respondents in the 'formal sector' stressed the importance of training and education through addressing the issue of the lack of awareness by Rwandan citizens, the level of education and skills of workers, the need to create environmental awareness by youth and training for local investors about the circular economy. In line with education, the importance of research was stressed, due to limited knowledge about the process of growing black soldier flies. In addition, one respondent located in Rwanda stated that it takes three years to register organic fertilizers with RAB, so the company stopped with the administrative process. Furthermore, two

respondents stated challenges around water management. One Rwandan company stressed that floods wash away the sugarcane plantation, while another company stressed the challenges around the lack of water in the dry season in Rwanda. In addition, one company stated the challenges around the lack of cold storage transport to Kenya, which can result in food waste. Furthermore, it was stressed that there is a lack of alternatives for plastics.

> "It takes three years to register an organic fertilizer as a product by RAB". Input supplier in East Africa.

4.4 Solutions of implementing a circular economy in the agricultural sector in East Africa

This section discusses the different typologies of interventions towards the circular economy, namely technical, financial/market, institutional/regulatory, organizational, social/cultural, environmental and other identified solutions through the survey of the 'formal sector'. Since these questions required insights of formal companies, these results are only answered by the 'formal sector' (paragraph 3.1)

In order to calculate the percentages of the different solutions for the 'formal sector', the respondents are asked to rank the importance of different solutions on a Likert scale from 1 to 6. A six (6) indicates that the solution is the highest important (great solution), while grade 1 indicates that a solution is not important. A percentage is calculated over the total 'formal respondent group' (paragraph 4.1) that indicated 1/2/3/4/5/6.

Technical solutions

This study seeks to understand how important different technical solutions are for companies to establish a circular economy business model. All technical solutions are ranked as important by the respondents (figure 63 and table 15). The solutions establish pilot projects in organizations/companies (total 96 percent), establish collaboration platforms in order to share knowledge and solutions e.g. through public-private partnerships (96 percent) and facilitates research to develop and improve (new) technologies and business practices through research experiments locations (test sides) and research budget is indicated as the most important technical solutions. The solutions that are indicated as most important from the respondents include: facilitate research (62 percent), establish pilot projects (58 percent), training for

professionals (58 percent) and change educational systems (58 percent). The need of research was also stressed by different respondents, for instance two black soldier farms stressed the need for research to monitor the process of breeding black soldier flies including the influence of humidity and temperature to improve the efficiency of the company. Furthermore, it was mentioned by the respondents that there is a need for demonstration/pilot projects at their company, for instance to demonstrate to customers that maggots can be used to feed the fish by the establishment of a fish farm or an experimental farm to test human waste (urine) as a fertilizer.

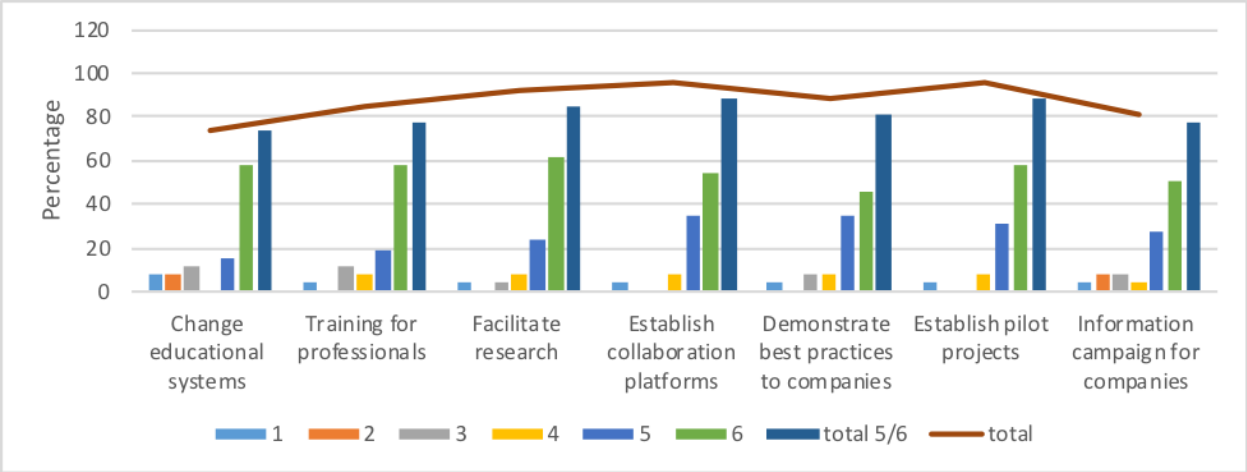

Figure 63. Overview of the importance of different technical solutions to establish a circular economy business model. Source: author

Table 15. Overview of the importance of different technical solutions to establish a circular economy business model.

	1	2	3	4	5	6	total 5/6	total
Change educational systems	7.7	7.7	11.5	0	15	57.7	73.1	73.1
Training for professionals	3.8	0	11.5	8	19	57.7	76.9	84.6
Facilitate research	3.8	0	3.8	8	23	61.5	84.6	92.3
Establish collaboration platforms	3.8	0	0	8	35	53.8	88.4	96.1
Demonstrate best practices to companies	3.8	0	7.7	8	35	46.2	80.8	88.5
Establish pilot projects	3.8	0	0	8	31	57.7	88.5	96.2
Information campaign for companies	3.8	7.7	7.7	4	27	50	76.9	80.7

Source: author

Financial and market solutions

Similar to the technical solutions, this study seeks to know how important different financial solutions are for companies to establish circular economy business models in the agricultural sector in East Africa (figure 64 and table 16). All financial/market solutions are ranked as important, however, initiate industry collaboration platforms (total 92 percent), establish

business support schemes (total 89 percent) and business competitions (total 85 percent) and business competition (total 85 percent) are indicated by the respondents as the most important financial/market solutions (figure 64 and table 16). One company stress that the respondent has done by business competition by itself, another respondent underlines that a business competition works like a soccer game it encourages the company to win the game.

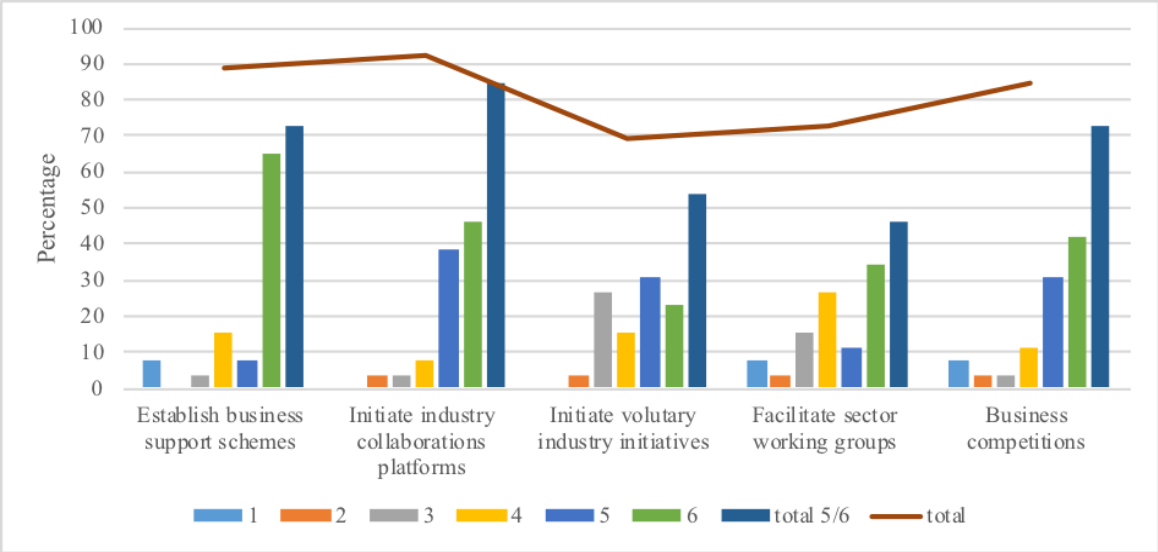

Figure 64. Overview of the importance of different financial/market solutions. Source: author

Table 16. Overview of the importance of different financial/market solutions.

	1	2	3	4	5	6	total 5/6	total
Establish business support schemes	7.7	0	3.8	15.4	7.7	65.4	73.1	88.5
Initiate industry collaborations platforms	0	3.8	3.8	7.7	38.5	46.2	84.7	92.4
Initiate voluntary industry initiatives	0	3.8	26.9	15.4	30.8	23.1	53.9	69.3
Facilitate sector working groups	7.7	3.8	15.4	26.9	11.5	34.6	46.1	73
Business competitions	7.7	3.8	3.8	11.5	30.8	42.3	73.1	84.6

Source: author

Institutional and regulatory solutions

Besides technical and financial/market solutions, this study also looks into institutional/regulatory solutions. The solutions that are ranked as most important are budget of 'the public sector invest in circular economy activities' (96 total percentage), 'introduce fiscal instruments to encourage circular activities/discourage non-circular activities' (92 total percentage), 'improve waste collection and recycling by establishing a waste collection infrastructure'(92 total percentage) and 'institutional and regulatory framework with common

ambition towards circular economy' (92 total percentage) (figure 65 and table 17). In line with the solution 'institutional and regulatory framework with common ambition towards a circular economy' the solution 'a policy framework with a strategic roadmap toward circular economy' is also ranked as important to important by 88.5 percent of the respondents. It is underlined by a respondent that it is important by the solution 'introduce fiscal instruments to encourage circular activities/discourage non-circular activities' to consider what kind of support non-circular companies receive to establish a more circular model to avoid that the company is punished.

> "What kind of assistance do companies receive to achieve a circular business model? Otherwise it will be like punishment, it is giving a penalty for not paying school fees".

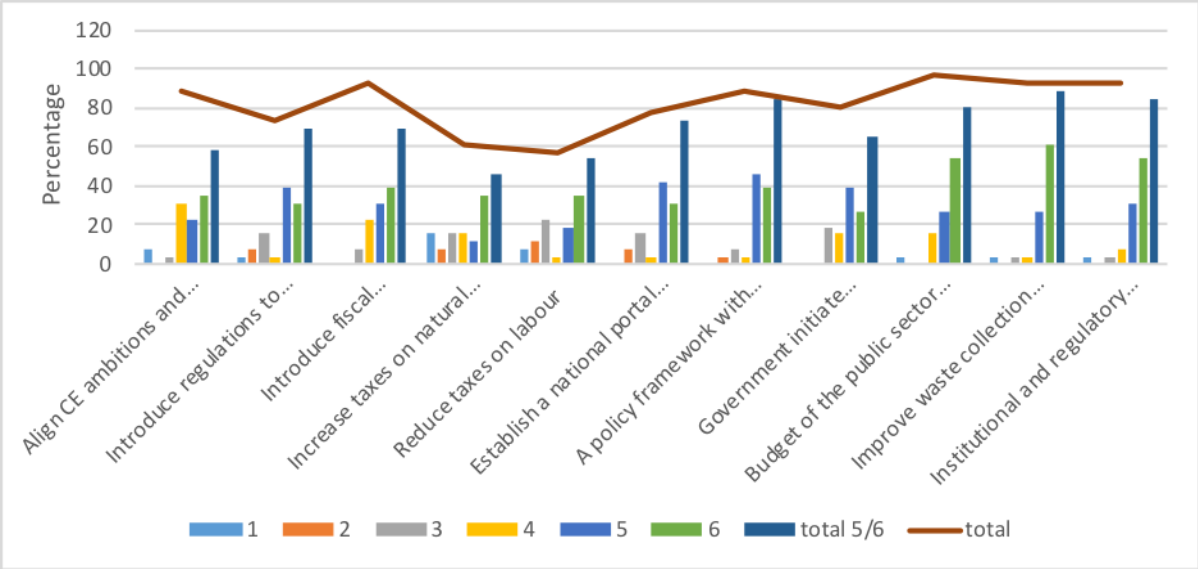

Figure 65. Overview of the importance of different financial/market solutions. Source: author

Table 17. Overview of the importance of different financial/market solutions. Source: author

	1	2	3	4	5	6	total 5/6	total
Align CE ambitions and policies with stakeholders from the beginning	7.7	0	3.8	31	23	34.6	57.7	88.5
Introduce regulations to encourage/discourage (non)-circular activities	3.8	7.7	15.4	3.8	39	30.8	69.3	73.1
Introduce fiscal instruments to encourage circular activities/discourage non-circular activities	0	0	7.7	23	31	38.5	69.3	92.4
Increase taxes on natural minerals	15.4	7.7	15.4	15	12	34.6	46.1	61.5
Reduce taxes on labour	7.7	12	23.1	3.8	19	34.6	53.8	57.6
Establish a national portal for circular business models	0	7.7	15.4	3.8	42	30.8	73.1	76.9
A policy framework with strategic roadmap toward CE	0	3.8	7.7	3.8	46	38.5	84.7	88.5
Government initiate concrete & simple steps	0	0	19.2	15	39	26.9	65.4	80.8
Budget of the public sector invest in CE activities	3.8	0	0	15	27	53.8	80.7	96.1
Improve waste collection and recycling by establishing a waste collection infrastructure	3.8	0	3.8	3.8	27	61.5	88.4	92.2
Institutional and regulatory framework with a common ambition towards CE	3.8	0	3.8	7.7	31	53.8	84.6	92.3

Organizational solutions

Industry collaboration platforms of the technical barriers can be considered as an organizational solution (figure 64 and table 16).

Social and cultural solutions

About 92 percent of the respondents considered the intervention 'awareness campaign to inform the public and communities about the benefits of circular economy practices and products' important to highly important (figure 66).

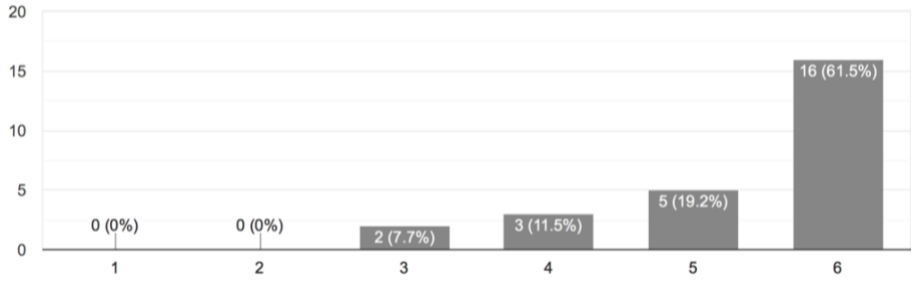

Figure 66. Overview of the importance of 'awareness campaign to inform the public and communities about the benefits of circular economy practices and product' to establish a circular economy business model. Source: author

Other solutions

In addition to the earlier described solutions, the respondents also had the opportunity to provide additional solutions. Two respondents stressed that there is a need for a larger institutional approach. The first respondent stated that there is a need for a national fund for a circular economy and recycling practices. All companies should pay a membership fee to the fund and the fund actively searches for circular economy solutions and provides financial capital to companies to implement solutions with collaborating organizations. The respondent stressed that the company is focused on productivity and is not a circular economy expert. The second respondent stated that there is a need for a circular economy institution that organizes projects and awareness creation about the circular economy concept, especially since the concept is not widely known. Furthermore, a respondent expressed that there is a need to establish circular economy incentives and to recycle waste, for instance the company receives green award/certificate for being an environmentally friendly company and receives a small economic incentive per month for waste collection. Moreover, it is underlined that all companies should work together for circular economy practices and that education and youth should be included to

create circular economy solutions. Furthermore, it is stated that there is collaboration needed between education, research and incentives such as giving grants or funding circular economy business models to push the circular economy model.

Furthermore, respondents underlined circular economy solutions in food systems that could be implemented by the private sector. Respondents stated that more value can be added after the collection of organic waste, such as bio briquettes, animal feed and transformation of the waste of restaurants into compost. Furthermore, waste from pigs can be used to produce biogas or other forms of energy or use waste to grow algae to convert it into biofuel. It was also stated that there is a potential to set up social enterprise activities in the utilization of human waste as a fertilizer and to improve the income and food security of local farmers which can be done through an experimental farm. In addition, it was stated there is a need for a company that process manure of cattle into fertilizers to grow tea. Moreover, it was stressed that there is a need of a sewage system in Kigali city, which collects and recycles wastewater.

4.5 Summary

This section seeks to provide a brief overview of the most important empirical research findings. Although, this paragraph does not aim to provide an in-depth reflection, since results already presented in this section are followed by an in-depth interpretation of the results in the discussion.

The implementation of a circular economy

Circular economy practices in the 'informal sector' are mostly implemented by the use of organic waste of compost as fertilizer (67.5 percent of all actors). Furthermore, utilization of organic waste residues of processing activities is used as animal feed (45 percent of all actors). The technique to store, collect and separate different crops and waste materials is applied by the reuse of containers, baskets and equipment by different actors. Recycling practices are applied by the use of agricultural bags and jerry cans in daily agricultural activities. Input suppliers recycle old papers into paper bags for selling products. About 30 percent of the actors indicated applying recycling practices, however the observed recycling practices are higher (figure 26). It was rare that respondents reported use of renewable resources (solar lights) in their business

activities (about 14 percent). In contrast of the 'informal sector', 54 percent of the respondents of the 'formal sector' use different forms of renewable resources as input for energy in their business activities. Furthermore, 15 percent of the respondents of the 'formal sector' make use of 'partial chain integration' business model (residues of one business are used to produce another product) followed by another 31 percent that have developed a business model that aims to design a circular end-product.

About 81 percent of the actors in the 'formal sector' work together related to waste and recycling versus 37 percent of the respondents in the 'informal sector'. There are eight different collaborations forms identified in the 'informal sector' related to waste, namely formal waste through a company and informal waste collection by a person who sells waste. Furthermore, waste is provided for free/sold to customers by retailers and input suppliers or (human) waste is bought/utilized to produce compost/human waste fertilizer. On top of that, farmers established exchange collaborations between farmers, waste is collected to process it into animal feed, and organic waste of processing activities is used by the actor itself in farming activities. There are five different collaboration forms identified for the 'formal sector' which also includes informal waste collection through informal businessmen and local markets, formal waste collection through other company and that the companies sell' waste. Similarly, as the 'informal sector' the formal sector collects waste for free/buys it, although this relationship is more frequently identified in the 'formal sector'. An important difference between the results of the 'informal sector' and 'formal sector' towards the collection of organic waste is the focus on waste collection as input for business activities. In the 'informal sector' not more than five percent collect waste as input for business activities compared to 42 percent of the respondents in the 'formal sector'.

Implementation barriers

As presented in this section, the 'informal sector' receives significant less technical, financial, organizational, social-cultural and policy support than the 'formal sector' (figure 35). There is especially a large difference in technical support since only 9 percent of the 'informal sector' receives technical support compared to 65 percent of the 'formal sector'. This similarly applies to policies, since only 6 percent of the 'informal sector' is impacted by policies compared to 54 percent of the 'formal sector'. One of the most important barriers that is stated by the 'informal

sector' itself is the lack of knowledge and organic waste quantity to produce high-quality compost. Although the 'formal sector' receives significantly more support than the 'informal sector', the 'formal sector' still faces implementation barriers towards a circular economy. The most important barriers for circular food systems are ranked by the 'formal sector' (table 18).

Solutions

The most important solutions for circular food systems are marked by the 'formal sector' (table 19). As described earlier, the ranking of the most important solutions is only done by the 'formal sector', due to the educational background of the 'informal sector' (paragraph 3.1). Although the need for an improved waste collection infrastructure (table 19) is also stressed by the 'informal sector'. The interpretation of the solutions is further discussed in the discussion and conclusion.

Table 18. Overview of the most important implementation barriers to establish a circular economy indicated by the formal sector.

Technical	**Financial/market**	**Institutional/regulatory**	**Organizational**	**Social/cultural**
Lack of appropriate technologies to implement a circular economy business mode	Large capital requirements and high initial cost for establishing a circular economy business model	The insufficient public good/infrastructure e.g. there is no formal infrastructure for waste collection/recycling	The insufficient public good/infrastructure e.g. there is no formal infrastructure for waste collection/recycling	Customers are not used to products/services with circular business model due routines and limited environmental awareness and education'
Lack of skilled workers, technical support training and knowledge to establish a circular economy model		Lack of government investment to establish a circular economy'		
		Implementation and enforcement failures of policies related to waste, recycling and renewable resources'		

Source: author

Table 19. Overview of the most important solution for circular food system indicated by the respondents of the formal sector.

Technical solutions	**Financial/market solutions**	**Institutional/regulatory solutions**	**Organizational**	**Social cultural**
Pilot projects in organizations/companies	Initiate industry collaboration platforms (industrial symbioses programmes) that have the purpose to develop cooperation in an industry where unused or residual resources are used by another	Budgets of the public sector invest in circular economy activities'	Industry collaboration platforms	Awareness campaign to inform the public and communities about the benefits of circular economy practices and products as
Collaborations platforms in order to share knowledge and solutions e.g. through public-private partnerships	Business support schemes	Introduce fiscal instruments to encourage circular activities/discourage non-circular activities		
Facilitate research to develop and improve (new) technologies and business practices through research experiments locations (test sides) and research budget	Business competitions	Institutional and regulatory framework with common ambition towards circular economy.		
Establish pilot projects in companies'		Improve waste collection infrastructure		

5. Discussion and conclusion

This section aims to answer research question '*What are the barriers, drivers and solutions to implement a circular economy in the agricultural sector in East Africa in order to meet the challenges of the Sustainable Developments Goals (SDGs) 2, 12 and 13?*' and the sub-questions that are mentioned in paragraph 1.4. In order to answer the main research question the discussion follows the following outline:

5.1 Circular economy in theory and in practice
5.2 Implementation barriers in theory and in practice
5.3 Solutions in theory and in practice
5.4 Reflection on the methodology
5.5 Further reflection
5.6 Conclusion
5.7 Further research

5.1 Circular economy in theory and practice

Theory

An alternative model for the traditional linear model that is focused on 'take-make-dispose' is a circular economy. A circular economy is "an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models" (Ellen MacArthur Foundation, 2013, p. 7). The circular economy rest on three principles, namely design out waste, keep products and materials in use (re-use and recycle), and regenerated natural systems (Ellen MacArthur Foundation, 2019).

The literature about circular economy about agriculture refers to a wider concept, namely circular food systems. WUR (n.d.) describes a circular food system as "keep residuals of agricultural biomass and food processing within the food system as renewable resources". Scholten et al., (2018) specified the concept more and stress that circular agriculture is an integral part of a circular food system within a 'bio-base' society, therefore it requires a system approach and to study the whole value chain. A system approach requires the inclusion of

different scales (scope and time). For instance, it is essential to close circular agriculture at local scale. However, for national or global food production system different local cycles need to be closed and connected (Scholten et al., 2018). Furthermore, a systems approach is not only focused on one value chain, but also on cross value chains, industries and other aspects of the food system. Especially since by-products can be used in different ways or are coming from processers, such as food waste or losses from bakeries or restaurants. Furthermore, circular food systems in urban areas require collaboration between different stakeholders, such as private and public sector collaboration to establish a circular food system in countries and regions (Ellen MacArthur Foundation, 2019).

Practice

The research findings have shown that some circular economy practices are already implemented in Rwanda's food system. A circular economy is mostly implemented by the utilization of organic waste of compost as fertilizer. Furthermore, farmers use organic waste residue from processing activities as animal feed. The technique to store, collect and separate different crops and waste materials is seen in the reuse of containers, baskets and equipment by different actors. Recycling practices are applied by using agricultural bags and jerry cans in daily agricultural activities. Input suppliers recycle old papers into paper bags for selling products. It is very rare that respondents use renewable resources (solar lights) in their business activities. Many actors use firewood (biomass) as input for cooking at home, however, in this study this not considered as a business activity. Furthermore, it is questionable if the use of firewood can be seen as part of a circular economy.

Consequently, a circular economy in agriculture in Rwanda is mostly focused on the first (design out waste) and second principle (re-use and recycle materials) based on the earlier mentioned circular economy principles. About 37.5 percent of all respondents already work together with other actors in the food value chain related to their waste. Despite that there are already circular economy practices in place, there is still a great potential for further improvements in the 'informal sector'. Improvements that are suggested by the actors includes access to compost or human waste as natural fertilizers in order to increase the yield and gathering dumped waste of the village or (organic) waste from the farmers together including manure in order to produce compost. In addition, processors stated the potential to process

organic waste into animal feed, while other respondents stressed the opportunity to sell organic waste of their business activities as animal feed.

Although it was not the intention of this study to answer the status of a circular economy in the 'formal agriculture' in East Africa in-depth, this study can still provide insights from the research findings. The research findings show that some circular economy practices are already implemented in the East African food systems. In contrast to the 'informal sector', the 'formal sector' is not mostly focused on the first (design out waste) and second circular economy principle (keep products and materials in use), but also on the third principle (regenerative systems). For instance, some actors implement aquaponics, agroforestry or multi-species systems, which is the third circular economy principle. About 81 percent of the respondents have some form of circular economy business model, which are mostly business models that apply in-house circularity or companies that design circular food systems innovations such as growing insects on organic waste as animal feed or the production of compost/organic fertilizers. Furthermore, the level of collaboration between actors or businesses related to waste and recycling in the 'formal sector' (81 percent) is significantly higher compared to the 'informal sector' (37.5 percent). An important difference between the results of the 'informal sector' and 'formal sector' towards the collection of organic waste is the focus on waste collection as input for business activities. In the 'informal sector' not more than five percent of the actors collect waste as input for business activities compared to 42 percent of the respondents of the 'formal sector'.

It can be concluded from the research findings that circular economy in agriculture in the 'formal sector' is implemented at a higher level than in the 'informal sector', which can be explained by the difference in the level of education and the access to different types of resources. This is further discussed in paragraph 5.2.

5.2 Implementation barriers in theory and in practice

Theory

The literature describes six different typologies of determinants towards the transition of a circular economy, namely technical, financial/market, institutional/regulatory, organizational, social and environmental barriers, and drivers. All these typologies can be either driver or barrier (determinants) towards the transition to a circular economy. The literature stresses that a holistic

approach is needed for the successful implementation of a circular economy, which includes all determinants for the implementation of a circular economy (De Jesus & Mendonça, 2018). Although the studies provide the relevance of these determinants, the understanding of how these factors are relevant and apply in the circular agricultural sector in East Africa is limited. Especially since the studies provide general drivers, barriers and solutions that are not applied to the African context in agriculture. Given the importance of determinants towards a transition to a circular economy in agriculture, this study argues that there is a great academic research gap towards the barriers, drivers and solutions in the agricultural sector in East Africa. Therefore, it is important to understand how these factors apply in the agricultural sector in East Africa and which other barriers, drivers and solutions are relevant in order to accelerate the transition towards circular agriculture in East Africa.

Practice

The identified barriers of implementing a circular food system in Rwanda are found to be in all of the six typologies of determinants. For instance, there is a great lack of technical support, since only 9 percent of the respondents receive support from institutions to enhance their business activities through training, information or technologies. However, current received technical support by the respondents is not related to circular economy practices. This can also be explained by the fact that farmers stated their lack of knowledge and organic waste quantity to produce high-quality compost. Furthermore, there is a lack of understanding and awareness about the term ‘recycling’ by the respondents. Many respondents even stressed, that it was their first time that they are approached to discuss waste and recycling topics. This indicates that there is a lack of awareness about the circular economy concepts and their potential. Other implementation barriers include the current limited financial support, since only 37.5 percent of the actors receive financial support, which makes it difficult to invest in the technologies and required equipment to establish a circular business model. There is especially a lack of financial support for farmers and collectors. Furthermore, there is almost no existing policy framework related to waste management, recycling or renewable resources. In addition, there is an institutional barrier towards the lack of support in interconnecting actors for circular economy practices. Moreover, there are almost no community activities related to organic waste-management, recycling or the use of renewable resources, since only 5 percent of all actors are

impacted by community activities that are related to a circular economy. The current community activities are mostly focused on plastics, hygiene and construction of the roads. Other relevant implementation barriers include the influence of the seasons in the quantity of organic waste and the need for animal feed during rainy seasons. Furthermore, transport barriers play a role since the transport of organic waste or manure can be heavy.

In contrast, it can be suggested from the research findings that the 'formal' agricultural sector in East Africa has significant more access to technical, financial institutional support in interconnecting actors for circular economy practices, and are more affected by policies and regulations related to circular economy practices than the 'informal' agriculture in Rwanda. Therefore, it could be suggested from the research findings that the 'informal agricultural sector' faces higher barriers towards the implementation of circular economy in the agriculture sector than the 'formal agricultural sector'. This can be explained by the fact that the actors in the 'informal sector' are less educated (primary/secondary) than the actors in the 'formal sector' (96 percent at least bachelor educated), which results in lower access to fundamental resources for development. The crucial role of education in social-economic benefits in development is also stressed in the literature (Ozturk, 2001).

The 'formal agricultural sector' also faces significant barriers towards the implementation of circular economy practices in the East African food systems. Similar to the 'informal sector', this study identified all six typologies of determinants as barriers to the 'formal sector' experiencing in implementing a circular economy in East Africa. For instance, the lack of skilled workers, technical support and knowledge to establish a circular business model is underlined as a significant important technical barrier to establish circular economy business models. Remarkable is that path-dependency in technologies, specialized knowledge and investments are not considered as an important barrier, which can be explained by the fact that 64 percent of the interviewed agricultural companies are younger than five years. Path-dependency (in technologies, specialized knowledge and investments) might not play a crucial role in African companies, since the African continent has the world's youngest population that is characterized by an emerging economy (Mathew, 2014). Emerging economies in less industrialized countries, may not be as strongly committed to the linear economy as high industrialized countries. Therefore, the potential to a establish circular economy in East African countries might be higher due to the lack of path dependency towards previous technologies, specialized knowledge, and

investments based on a traditional linear model. This is especially relevant for agriculture since agriculture is the backbone of the economy in East Africa (East African Community, 2010).

Furthermore, the research findings suggest that large capital requirements and high initial costs to establish a circular economy model can be considered as the most important financial barrier. This research finding also explains why business schemes (financial capital) are suggested as one of the most important financial solutions. Remarkable is that the financial barrier 'circular business models are not profitable' is considered by 77 percent of the respondents as not important, which means that circular economy business models are considered as profitable by the respondents. In contrast to the 'informal sector', the 'formal sector' is affected by laws, regulations related to waste and recycling. However, the current implementation and enforcement failures related to waste and recycling are seen as a barrier by 65 percent of the respondents of the formal sector. This can be explained why a common ambition towards a circular economy is considered as one of the most important institutional/regulatory interventions. Respondents especially stressed the lack of separation in the waste collection as a policy implementation and enforcement failure. Consequently, 'the lack of proper waste collection infrastructure/insufficient goods' is considered as one of the most important barriers towards the implementation of circular food systems. The importance of waste collection and separation at the source is also confirmed by the 'informal' agricultural sector. Other barriers that were underlined by the respondents of the 'formal agricultural sector' include the lack of alternatives and clear vision for (agricultural) companies that are affected by the introduction of single-use/plastic bag bans. On top of that, long administrative procedures to register circular economy innovations (organic fertilizers) are stressed as a barrier. Both barriers can be considered as an implementation and policy failure of current policies related to circular economy practices. The lack of alternatives of plastics can be used as a business opportunity for companies to develop package material made from organic waste or agricultural by-products. At informal level this also includs the lack of knowledge about circular economy practices.

5.3 Solutions in theory and practice

Theory

Similar to the barriers, the literature describes solutions that are found in the earlier mentioned six different typologies namely technological, financial/market, institutional and regulatory, organizational, social/cultural and environmental solutions. These solutions have the intention to overcome the implementation barriers towards the transition of a circular economy, which is a fundamental change. As mentioned earlier, the literature stresses that a holistic approach is needed for the successful implementation of a circular economy, which includes a wide range of solutions for a successful implementation towards a circular economy (de Jesus & Mendonça, 2018). Although the studies provide the relevance of these solutions, the understanding of how these solutions are relevant and apply in the circular agricultural sector in East Africa is limited. Especially since these solutions are not applied to the African context of circular food systems.

Practice

Since the research findings suggest that there is a lack of appropriate policy framework and proper interventions related to waste, recycling and renewable resources in the agricultural sector in East Africa, there is a great potential for possible interventions. Similar to the implementation barriers, solutions are found in all six typologies that are described in the existing literature.

The research findings of the survey with the 'formal' agricultural circular/non-circular companies in East Africa have shown that there is a great need for technical solutions to establish a circular economy in agriculture, since all technical solutions are marked as important to high important by at least 73 percent of the respondents. This can also be explained by the fact that the African continent, and East African countries specifically, are still lagging behind in development, education and belongs to the least skilled workforce of the world, This challenge requires interventions towards the gap in skills and education (Worldbank, 2017). Furthermore, the majority of farming practices are still based on traditional methods (East African Community, 2010) which requires new knowledge and practices to implement circular food systems.

The most important technical solutions are 'pilot projects in organizations/companies', 'collaborations platforms in order to share knowledge and solutions e.g. through public-private partnerships', 'facilitate research to develop and improve (new) technologies and business practices through research experiments locations (test sides) and research budget' and to 'establish pilot projects in companies'. Collaboration platforms can also be considered as

organizational solutions since they encourage the interconnection of different stakeholders to work on circular economy practices. Furthermore, the interventions to change educational systems and 'training for professionals that work in/related to agriculture about the circular economy concept and circular food systems' are highly valued. Similar to the 'formal sector', the 'informal agricultural sector' also underlines the need for training about circular economy practices.

Furthermore, the results of the 'formal' agricultural sector suggest that financial/market support is significantly important to establish a circular economy in the agricultural sector. Especially the solutions 'initiate industry collaboration platforms (industrial symbioses programmes) that have the purpose to develop cooperation in an industry where unused or residual resources are used by another', 'business competitions' and 'business support schemes' are significant important. This also can be explained by the fact that new business initiatives (either through business competitions, industry platforms or other initiatives) need financial support, especially in the African emerging economies (AfDB, 2013). Furthermore, industry collaboration platforms can also be considered as organizational solutions, since it encourages the private sector to work together.

On top of that, research findings have shown that the most important institutional/regulatory interventions are the 'budgets of the public sector invest in circular economy activities', to 'introduce fiscal instruments to encourage circular activities/discourage non-circular activities' and 'improve waste collection infrastructure' and 'institutional and regulatory framework with common ambition towards a circular economy'. The relevance of the 'solution common ambition towards a circular economy' is also confirmed by the barrier 'implementation and enforcement failures of policies related to waste, recycling and renewable resources' since it indicated as a significant important barrier. Especially the solution 'improve waste collection infrastructure' is underlined as one of the most important solutions, since the companies face challenges to collect and separate waste. The importance of proper waste collection infrastructure is also underlined by the respondents of the 'informal agricultural sector'. Furthermore, awareness campaigns to inform the public and communities is also a significant important cultural/social solution to establish a circular economy.

The research also uncovered solutions for circular food systems that were not mentioned in the previous literature. The uncovered solutions stated that institutional support should go

further than policies and regulations, since there is a need for a circular economy institution for awareness creation, research and circular economy projects. Following that, a national circular economy fund is needed for circular economy projects established through a membership. In addition, it was suggested by a respondent that there is a need for a green certificate for being an environmentally friendly company, this could be one of the tasks of the circular economy institution.

If the uncovered solutions are combined with the earlier mentioned solutions the institution could serve as a key role to bring the private sector, government, research institutions and investors together for a common ambition towards the transition to a circular economy, especially for circular food systems. This institution should play a key role to establish collaboration platforms, facilitate research and research budgets, pilot projects inside companies which could be an experimental area for researchers. Furthermore, the institution should help to initiate 'business competitions' and 'initiate industry collaboration platforms', which can result in new circular business initiatives. These business initiatives should be encouraged by 'business support schemes' for financial capital for the private sector. These circular initiatives could be further encouraged by the institution through collaborations with other government institutions to 'introduce fiscal instruments to encourage circular activities', 'improve waste collection and separation infrastructure' and 'institutional and regulatory framework and to develop a common ambition towards a circular economy'. The suggested solutions should be implemented in a holistic approach, since a circular food system can only be successfully applied by combining the suggested solutions. This is in line with the current literature about the implementation of a circular economy (de Jesus & Mendonça, 2018) and by the respondents. In order to facilitate a successful transition towards circular food systems it is important to consider the differences between 'informal' and 'formal' agricultural sector in East Africa especially since the 'informal' sector face significantly higher barriers towards the transition. Furthermore, interventions should not only focus on the use of agricultural by-products, organic waste, but also through regenerative agriculture since this is also part of circular food systems.

5.4 Further reflection

This research can be further reflected through an in-depth reflection of the previous theory and methodology.

It can be concluded that some aspects of a circular economy theory can be further clarified for circular food systems. The literature makes use of three principles to explain a circular economy, which is to design out waste, re-use materials and regenerative systems (Ellen MacArthur Foundation, 2018). Although re-use of material and recycling is part of the same circular economy principle, in theory 're-use' and 'recycling' are two different 'terms'. According to the literature, re-use means that "products or components that are not waste are used again for the same purpose" (Eurostat, 2019, para 1), while recycling is a "recovery operation whereby waste materials are reprocessed into products, materials or substances whether for original or other purposes" (Eurostat, 2014, para 1).

However, the difference between the terms 're-use' and 'recycling' is not always clear in practice in agriculture in East Africa contexts. For instance, an agricultural bag that is designed by the manufacture of fertilizer as package material and is now used to store crops and fruits by a retailer can be considered as recycling. Although an agriculture bag that is bought on the market to store crops and fruits directly can be considered as re-use. As a result, the difference between the term 'recycling' and 're-use' is not always clear in the field, which makes it difficult to study the difference in practice, especially since actors are not aware of the difference between re-use and recycling. It is also remarkable that the term 'recycling' is used in projects to describe a circular economy, for instance 'recycling of nutrients', while it is stressed by the Ellen MacArthur Foundation (2018) the use of by-products or organic waste is considered as the first principle 'design out waste'. Some scholars positions recycling as the last solution of a circular economy and part of the second circular economy principle (Ellen MacArthur Foundation, 2013), while others use the term 'recycling' to explain a circular economy (Kircherr et al., 2017). This suggests that there is no alignment between different theories about the meaning of a circular economy and the term 'recycling'. The different interpretation of the circular concept and their principles is also stressed in the literature (Kirchherr et al., 2017).

Furthermore, there is a lack of theory or other forms of available documentation what the 'requirements' are of circular economy cases in food systems. For instance, a company burns organic waste to produce organic fertilizers, which results in emissions during the production of

organic fertilizers. This case is considered and documented by circular economy experts as a circular economy business model. However, it is questionable if this can be considered as a circular innovation, since it results in emissions. The development of criteria what a circular economy business models means in practices could help to clarify these questions. Furthermore, these criteria could provide guidelines towards proper circular economy cases that could be further encouraged by policies and regulations.

In regards to the used methodology, a couple of notes can be made. First of all, it was not always possible to observe the interviewed actors of the cassava value chain, since some actors were under represented in the field. For instance, collectors could not be observed since the actors were not easy to identify and most of the collectors were not around their collecting facility. Since some respondents were under represented in the field (input suppliers, collectors), the study could not reach a number of twelve input suppliers and collectors. However, an intervention would have interrupted the sampling method in Kamonyi District (snowball example), therefore it is chosen not to interfere in the sampling method as a result that almost no collectors could not be observed in this study. Therefore, the answers of the most collectors could not be verified with the observations. Furthermore, there are restrictions in data-collection in the field, since enumerators are used to translate the questions and answers of the respondents from English to Kirwanda and the opposite, which means that the researcher receives a summary of their answers.

Secondly, the respondents of the survey with circular/non-circular companies are identified through a snowball methodology as well. It was clear that the snowball methodology was more successful in Rwanda and Tanzania, than in Kenya. The researcher had the ability to be physically present during the data-collection in Rwanda and Tanzania, therefore it was much easier to follow up with the respondents and key contact persons. In addition, the researcher also tried to collect data for Uganda through contacts of ACEN network in Uganda and other keypersons, unfortunately, the respondents did not reply on the requests. In addition, the ACEN network was much more active in Rwanda and in Tanzania than Kenya in the data collection period, therefore it was easier to identify respondents in active countries.

5.5 Conclusion

An alternative model for the traditional linear model that is focused on 'take-make-dispose' is unsustainable, making the circular economy model a fitting alternative. A circular economy is "an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models" (Ellen MacArthur Foundation, 2013, p. 7). The concept of a circular economy is based on three principles, namely "design out waste, keep products and materials in use (re-use and recycle) and regenerate natural systems" (Ellen MacArthur Foundation, 2019, p. 24).

The research findings show that some circular economy practices are already implemented in Rwanda's 'informal' and East African 'formal' food systems. In Rwanda, a circular economy is mostly implemented by using organic waste of compost as fertilizer. Another circular economy practice is the use of organic waste residues of processing activities are used as animal feed. The technique to store, collect and separate different crops and waste materials is applied by the reuse of containers, baskets and equipment by different actors. Recycling practices are applied by using agricultural bags and jerry cans in daily agricultural activities. Input suppliers recycle old papers into paper bags for selling products. It is very rare that respondents use renewable resources (solar lights) in their business activities. Consequently, a circular agriculture in Rwanda is mostly focused on the first (design out waste) and second circular economy principle (re-use and recycle materials).

It can be suggested for the results that a circular economy in the 'formal' agricultural sector in East Africa is implemented at a higher level, since 81 percent of the actors work together related versus 37.5 percent of the respondents of the 'informal' agricultural sector in Rwanda. This also acknowledges the fact that the 'formal sector' is more actively focused on collaborations to collect waste (42 percent) as input for business activities than the 'informal sector (not more than 5 percent). Furthermore, the 'formal agricultural sector' is not only focused on first and second principles but also has implemented circular economy practices through regenerative farming. For instance, some actors implement aquaponics, agroforestry or multi-species systems, which is the third circular economy principle. About 81 percent of the respondents have 'some form' of a circular economy business model that applies in-house

circularity, work with companies related to residues or the actors' company produce circular innovations. For example, in-house circularity is applied through the use of organic waste as compost or energy for an actor's own company, while other companies produce a circular economy product at commercial scale (e.g. compost or insect-based animal feed). Despite the existing circular economy practices in place, there is still great potential for further improvements.

The literature describes six different typologies of determinants towards the transition of a circular economy, namely technical, financial/market, institutional/regulatory, organizational, social and environmental barriers, and drivers**.** It can be concluded that the identified barriers of implementing a circular food system in the 'informal' agricultural sector Rwanda and in the 'formal' agricultural sector in East Africa are found to be in all of the six typologies of determinants. Although, it can be suggested from the research findings that the 'formal agricultural sector' in East Africa has significant more access to technical, financial and institutional support in interconnecting actors for circular economy practices than the 'informal sector'. Furthermore, the 'formal' sector is higher affected by policies and regulated related to circular economy practices than the 'informal' sector in Rwanda. Therefore, it could be suggested from the research findings that the 'informal agricultural sector' faces higher barriers towards the implementation of circular economy in the agricultural sector than the 'formal sector', which can be explained in part by the difference in the level of education of the actors.

The most important implementation barriers toward circular 'formal' food systems in East Africa include the lack of skilled workers, technical support and knowledge, large capital requirements, and high initial cost to establish a circular economy business model. Other important implementation barriers include the current implementation and enforcement failures related to waste, recycling and renewable energy, which is in line with the barrier of the lack of proper waste collection and separation infrastructure/insufficient goods. Furthermore, the respondents also mentioned other barriers such as long administrative procedures to register circular economy innovations for circular food systems and the lack of alternatives for plastics after the introduction of bans for certain types of plastics hampers the transition. At the 'informal level' this also includes a lack of knowledge about circular economy practices and organic waste quantity to produce high-quality compost. The quantity of waste is also influenced by transport

barriers of waste and the influence of the seasons, which results in a different demand for animal feed.

Policy implications

Since the research findings suggest that there is a lack of appropriate policy frameworks and proper interventions related to waste, recycling and renewable resources in the agricultural sector in East Africa, there is a great potential for possible interventions. Similar to the implementation barriers, solutions are found in all six typologies that are described in the existing literature.

It is suggested that most important technical solutions are 'pilot projects in companies', 'collaborations platforms in order to share knowledge and solutions e.g. through public-private partnerships', 'facilitate research to develop and improve (new) technologies and business practices through research experiments locations and research budget'. Furthermore, training for professionals that work in/related to agriculture about a circular economy concept and circular food systems and other technical solutions are highly valued. Other significant important solutions include to 'initiate industry collaboration platforms (industrial symbioses programmes) that have the purpose to develop cooperation in an industry where unused or residual resources are used by another', 'business competitions' and 'business support schemes to support circular business initiatives. Consequently, there is a need for 'budgets of the public sector invest in circular economy activities', to 'introduce fiscal instruments to encourage circular activities/discourage non-circular activities', 'to improve waste collection infrastructure' and 'institutional and regulatory framework with common ambition towards a circular economy'.

In conclusion, a holistic approach is needed that combines technical, financial/market, institutional/regulatory, social/cultural solutions, which could be done through and circular economy institution with a national fund for circular economy initiatives. Solutions should include all six typologies of the determinants since solutions can be found in all typologies. Circular economy is an approach that requires a common ambition of the government, private sector and research institutions. In order to establish a circular food system there is a need of a central coordination within the government to achieve a successful transition. Therefore, this study concludes that there is a need for national program for circular food systems/circular economy institutions.

It is suggested that the national program for circular food systems should at least implement the following interventions:

- Establish industry and collaboration platforms to share knowledge and solutions. For example, public-private partnerships between universities, knowledge institutions, and government in order to support research questions of the private sector. In addition, a national program should facilitate private sector cooperation where unused or residual resources of one company can be used by another company. These collaborations can either be achieved at (cross) value or at industry level.
- Support research programmes and pilot projects for companies. In East Africa the circular economy is an approach that is not studied in-depth. Research should focus on to design and improvement of technologies and business practices through research experiments. In order to test and improve circular technologies and business practices, there is a need for pilot projects inside companies.
- Financial support for new businesses, industry initiatives and test pilot projects in companies through a special fund. A circular economy focused investment fund could also encourage companies to develop circular food systems initiatives by organizing business competitions.
- Introduce fiscal instruments (VAT) to encourage companies to develop circular business activities rather than taxes that discourage non-circular economy activities in lieu of waste or other social externalities. This is especially important since not all non-circular economy companies have immediate access to knowledge, technologies and resources to implement circular economy activities.
- Improve and enforce waste collection and separation infrastructure, since there is a lack of separation at the source, during transportation and handling of the waste. An improved waste collection infrastructure results in greater potentials to add value to waste and remove costs for circular business models.

At last, the national program for circular food systems should consider the difference between ‘informal’ and ‘formal’ agricultural sector in East Africa especially since the ‘informal’ sector face significantly higher barriers to achieve a successful transition. Furthermore, interventions

should not only focus on the use of agricultural by-products, organic waste, but also through regenerative agriculture since this is also part of circular food systems.

5.6 Recommendations for further research

This study is the first academic study that focuses on the barriers and solutions to implement a circular economy in the agricultural sector in East Africa in order to meet the challenges of the Sustainable Development Goals (SDGs) 2, 12 and 13. Since there is limited academic research about the circular economy concept (Korhonen et al., 2018), this study uncovers different aspects that requires further research. These recommendations include further research about the circular economy concept, recommendations for research about circular food systems and steps that could be done to accelerate the transition towards a circular economy.

Further research about circular economy and circular food systems

As mentioned earlier in paragraph 5.4 there is a need to clarify the concept circular economy further, especially around the practical difference between the terms ‘re-use’ and ‘recycling’, and the inconsistent use of the ‘term’ recycling in literature and practices towards the circular economy principles. Furthermore, it would be advisable to develop a metric tool to express the implementation of a circular economy at different levels with different scores, especially since a circular economy can be implemented at different levels (e.g. in-house circularity, partial integration, etc.) in practice. This metric tool could build on the theory of Jonker et al. (2017) which provides a loop ladder of different circular economy stages, although the difference between the different stages of the loop ladder in practice could be further defined. A metric tool could help researchers to improve research on circular economy and to test hypotheses with statistics by the development of a metric tool. Currently, this research was not able to find any proper metric tool to measure circular economy with statistics.

In addition, the introduction of a metric tool could also help to assess the utilization of organic waste and to simplify decision making by companies and policy makers. Different types of organic waste could be utilized for different circular innovations. For instance, organic waste can be used to grow black soldier flies to produce animal feed, while it also can be utilized to produce compost or organic fertilizers. However, there no information or tool was discovered in this research to help to determine which circular solutions transformed waste into the highest

possible value in an efficient way. In other words, a metric tool could help to compare the value of different circular solutions. Furthermore, a metric tool could prove an in-depth assessment by comparing different types of waste with each other. For instance, it was stressed by a respondent that organic waste of local breweries can be used to grow black soldier flies as animal feed, while unprocessed pineapple waste is not appropriate. Consequently, this requires more research about value addition of different types of organic waste (value chains). This should include research that monitors, improves, and documents circular agricultural solutions. A metric tool could help to make smart decisions for companies, but also for policy makers to encourage different circular economy solutions through policies. It also supports, the translation of circular economy solutions in economic benefits, which could help to convince governments, banks, investors and other private sector about the economic potential. A metric tool could help to unlock the circular economy potentials that result in new business initiatives, government involvement and employment potentials for youth.

Circular companies that depend on quantities of organic waste or food by-products can only exist when the companies have access to high quantities and qualities of organic waste at the right time in their production cycle. Currently, there is a great gap in the quantitative data about quantities and qualities of organic waste for East Africa. Therefore, there is more research needed about the available quantities and qualities of waste at household-, value chain-, and industry level. Concerning value chains, research could focus on the largest agriculture production value chains of the country to ensure high quantities of waste. Concerning household and industry level, most of the organic waste is consumed in urban areas. Research about available quantities and qualities is an important step towards the transition of circular food systems. Although, research should not only focus on organic and agricultural waste since regenerative farming systems are also part of circular food systems.

Cassava value chain

This research has collected qualitative data about quantities of organic waste per household per actor. Although, the reliability of the collected information is collected data is questionable since the data is not measured and estimated by the actors itself. It is recommended to collect quantitative data of quantities of organic waste in Rwanda, especially since the stakeholders of

the RUNRES project want to establish business activities that use organic waste (cassava peels) as input for circular economy innovations in Rwanda.

Acknowledgements

This research was supported by IITA Rwanda (International Institute of Tropical Agriculture) and funded through the RUNRES project. It was more than a pleasure to be part of this unique research project and to work on circular economy in food systems, which encourage my passion for circular food systems and food security further. I would like to express my gratitude to the RUNRES team and especially towards Dr. Haruna Sekabira for the great feedback, insights, guidance and enthusiastic support, and Ms. Speciose Kantengwa for the facilitation of the fieldwork. I would like to thank Dr. Marc Schut and Dr. Rhys Manners for the introduction to the RUNRES team.

Furthermore, I would express my appreciation to all respondents from traditional farmers, small scale processors to formal companies for their time, effort and their learned lessons. Without the input of the respondents it was not possible to do this study, especially since there is a great lack of data about circular food systems in East Africa. On top of that, I also would like to thank all important key persons for the support to identify new respondents for my research. Murakoze, asante sana (thank you).

A special thanks for my university supervisor, Prof Dr. Berry Tholen of Radboud University for the feedback, great support, patience and to give me the opportunity to work on my thesis from Rwanda. This opportunity has been an extremely important factor towards my happiness in my daily life in Rwanda and my futuristic career. At last, I would like to express my gratitude to my loving partner Professor David Ross for his feedback, incredible patience, and loving support in my career and in finishing my thesis.

It is a great wish that learned lessons of my research are scaled up and implemented. There is a great potential for circular economy practices in food systems in East Africa to unlock potentials for businesses, youth, food security and a green planet. Therefore, I would thank everyone who is interested in my research, since circular food system can be only achieved by collaboration.

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Attachments

Attachment 1. Observation scheme

Table 19. Observation scheme of the interactive observations for the 'informal sector'.

Date: Time: Situation:	Location: Attitude of the location: Observed actor: Name researcher:

Principle	Behavior	What	For which purpose	Number of times	Has potential to be design out/re-used/ regenerate	Why not	Comments
P1	The actor use waste as input(s) for a new product(s)						
P1	The actor use by-products of the products						
P1	The actor use biological materials that are non-toxic						
P2	The actor re-use materials, products and product parts						
P3	The actor recycles materials, products are their belonging parts.						
P3	The actor uses renewable resources where possible						

Attachment 2. Questionnaire by the interactive observations

Category	Question	
General information of the respondent	1.Name of the respondent	
	2.Name, and distance to the nearest bigger town center	
	3.What is the highest degree of education that have completed?	1 (Primary school) 2 (Secondary school) 3 (Bachelor) 4 (Master) 5 (Other, specify)
	4.What is your main business activity?	1 (Input supplier) 2 (Farmer/producer) 3 (Processor) 4 (Retailer) 5 (Wholesaler)
Sustainability of your company	This section would like to ask you some questions about the activities of your company related to related to waste, re-use, recycling and renewable resources.	
Environmental/ Technological	5.What kind of waste do you produce during your business activities?	*More than one answer possible:* 1 Liquid waste (dirty water/wash water/waste detergents) 2 (Organic waste) 3(Plastic packaging of used pesticides) 4 (Other plastic waste) 5 (Paper waste) 6 (Other, specify) 7 (Nothing)
	6.What happens to the waste (liquid waste/organic waste etc.) of your business activities?	*More than one answer possible* 1 (input for animal feed) 2 (input for energy for business activities) 3 (input for compost) 4 (input for organic fertilizer) 5 (Final dump) 6 (Other such as, specify)
	7.What do you recycle in your business activities?	*More than one answer possible* 1(agricultural bag) 2 (water) 3 (plastic packaging of used pesticides) 4 (Other, specify) 5 (Nothing)
	8.If yes in 7, for what purpose do you recycle (agricultural bags/water etc.)?	
	9.What kind of energy do you use in your business activities and for which purpose?	1 (electricity) 2 (biomass – energy from plants) 3 (solar energy) 4 (wind energy) 5 (hydro energy) 6 (Fuel) 7(No energy) 8 (Other, specify)
Organizational	10. Some middlemen are working together with other business men/women. For instance, organic waste of collection activities can be used for animal feed/fertilizers. Are you working together with other business partners related to your (organic) waste/recycling?	
	11. If yes in 10, how do you work together with other business men/women related to your waste? For instance, your organic waste is used as animal feed/organic fertilizers.	
	12. If yes in 11, what are the challenges in this form of collaboration? For instance, no demand for animal feed (waste) during raining season.	
	13. If yes in 12, are there any formal or informal institutions that support you with the cooperation between different partners of the value chain?	
	14. If yes in 13, what kind of institutions?	1 (Government) 2 (Private) 3 (Non-for-Profit international) 4 (local communities) 5 (Others, specify)
	15. If yes in 14, how do they support you?	
	16. If no in 13, how could they support you?	
Institutional support	This section would like to ask you some questions related to the current support of institutions (government, research, organizations) towards your company.	
Technical	17. Are there any organizations, research/government institutions providing you with new information, training or new technologies (communication, equipment, renewable resources etc.) to enhance the operations of your company?	
	18. If yes, what kind of organizations are providing support to your company?	*More than one answer is possible* 1 (Government) 2 (Private) 3 (Non-Governmental organizations) 4 (research institutions) 5 (local communities) 6 (consult) 7 (others)
	18. If yes, how do they support you?	
	19. If no, what could they do to support you?	
Institutional/regulations	20. Are there any laws/regulations/policies/norms guiding your business that you are aware about?	1 (Yes) 2 (No)
	21. If yes., how do they affect your business?	
	22. Are there any laws/policies/regulations related to your (organic) waste, reuse of materials, or recycling of waste that impact your business?	1 (Yes) 2 (No)
	23. If yes, how do laws/policies/regulations related to your (organic) waste, reuse of materials or recycling of waste that impact your business?	
Institutional organizational	24. Have you been approached/involved to provide input towards policies/regulations related to (organic) waste/recycling?	1 (Yes) 2 (No)
	25. If yes, how have you been involved? For instance, community meetings/stakeholder meetings.	1 (face to face meetings) 2 (community meetings) 3 (communication through phone) 4 (stakeholder meeting) 5 (project) 6 (Other, specify)
Social/cultural	26. *Are there any community activities that encourage you to do something with your waste/recycle your waste that you generate during your business activities? e.g Umuganda, if so what kind of activities and how does it affect your business activities?*	
	27. What keeps your clients committed to buying your products?	*More than one answer is possible* 1 (Price) 2 (Product performance)3 (Services) 4 (Other, specify)
	28. What are the challenges towards attracting customers for your product? (e.g price/competition/product performance etc.)	

Attachment 3. Survey questions for entrepreneurs

Thank you for agreeing to take part in this important survey that aims to identify challenges and solutions to integrate a circular economy in the agricultural sector in East Africa. An economy that is restorative or regenerative by intention and design and replaces the traditional 'take-make-dispose' economy. Your input is significantly important, especially since there are limited business cases that are operating in a circular economy in/related to agriculture in East Africa. Today, we will be gaining your thoughts and opinions in order to study which improvements can be made for achieving a circular economy in agriculture in East Africa in order to meet challenges of food security and climate change. This survey should only take 8-10 minutes to complete. After finalizing the research, a consolidated report will be shared and in case possibilities are opening up for referrals for donor/financial support these will be shared as well. All the answers that you provide will be kept in strictest confidentiality.

Survey questions entrepreneurs

Table 20. Questionnaire survey questions for the 'formal sector'.

Category	**Question**	
General information of the respondent	What is the name of your company?	
	Where is the company's main location located (village/city, country)?	
	What is your position within the company?	
	What is the highest degree of education that have completed?	1 Primary school 2 Highschool 3 Bachelor 4 Master 5 Other, specify
	What is your email address so that we can share a consolidated report afterwards?	
	Could you give us an overview on the different products and/or services your company offers around food systems/agriculture/agribusiness? (1-2 sentences)	
	How long does your company exist?	1 (0-1 year) 2 (1-2 years) 2 (2-3 years 3 (3-4 years) 4 (4-5 years) 5 (Other specify)
Sustainability of your company *(Environmental/ Technological)*	This section would like to ask you some questions about the activities of your company related to related to waste, re-use, recycling and renewable resources. With re-use we mean that products or components that *are not waste* are used again for the *same purpose*, while the recycling is recovery operation whereby *waste materials are processed* in materials, products or substances either for *original or other purposes*. For instance, an agricultural bag that used again for other purposes is recycling, while using the same basket again for the purpose is considered as the re-use of materials.	
	What type of waste is generated from your business activities?	*More than one answer possible* 1 Liquid waste 2 Plastic waste 3 Paper waste 4 Organic waste 5 Hazard waste 6 No waste 7 Other, specify
	Do you use waste as input for your business activities?	1 Yes; 2 No
	If yes, what kind of resource and for which purpose? e.g. you use organic waste as input for an organic fertilizer/production of animal feed.	*More than one answer possible* 1 Organic waste 2 Biogas 3Water 4 Other, such as
	Do you re-use products in your production process? If yes, how and for which purpose? e.g. *your company re-use the same baskets in the production process for the same purpose.*	1 Yes; 2 No
	Do you recycle in your business activities? *For instance, you use agricultural bags that were initially a packaging material for animal feed as storage for organic fertilizers.* If yes, how and for which purpose?	1 Yes; 2 No
	Do you use renewable resources in your production process?	1 Yes; 2 No
	If yes, what kind resource and for which purpose?	*More than one answer possible* 1 Solar energy 2 Wind power

		3 Biomass (energy from plants; e.g. using wood for cooking) 4 Hydro-energy 5 Other, such as
	Are there other sustainable practices technologies that you implement in your company that are not mentioned yet? If yes, how do you implement it and for which purpose? For instance, you use vertical farming in order to use less soil, water, and pesticides	
	Do you have plans/projects to do something actively with your waste or to use more sustainable input/resources in your business activities?	1 Yes; 2 No 3: I am already implementing a CE model/doing something with my waste
	If not, why not?	1: I am not interested 2: I never thought about doing something with my waste/circular business model 3 Other
	If yes, what would you like to do?	
Institutional support	This section would like to ask you some questions related to the current support of institutions (government, research, organizations) towards your company.	
Technical	Are there any organizations, research/government institutions providing you with new information, training or new technologies (communication, equipment, renewable resources etc.) to enhance the operations of your company?	1 Yes; 2 No
	If yes, what kind of organizations are providing support to your company?	*More than one answer is possible* 1 (Government) 2 (Private) 3 (Non-Governmental organizations) 4 research institutions 5 local communities (6 |(Consultant) 7 (others)
	If yes, how do they support you?	
	If not, what could they do to support you?	
Financial/market	Are there institutions willing to lend you in the production of your product?	1 Yes; No
	If yes, what kind of institutions?	*More than one answer is possible* 1 Formal (e.g. banks, microfinances etc.) 2 Government (e.g. government subsidies, loans etc.) 3 Non-governmental organizations 4 Informal (e.g. farmer groups, family etc) 5 Joint finance with other business in the value chain 6 Other, such as
Institutional/regulations	Are there any laws/policies/regulations related your waste, reuse of material, recycling or renewable energy that impact your company? For instance, it is obligation to separate your organic waste at your company.	1 Yes; 2 No
	How do laws/policies/regulations related to your waste, reuse of materials or renewable resources, recycling impact your company?	
Institutional/ organizational	Have you been involved/approached to provide input towards policies/regulations relevant to waste, reuse of materials, recycling, renewable resources etc.?	1 Yes; 2 No
	If yes, how have you been involved?	*More than one answer is possible* 1 face to face meeting 2 communication through phone/email 3 stakeholder meeting(s) 4 project 5 survey 6 other, such as
Organizational	Some companies are working together with companies in the value chain, for instance a company makes use of waste of restaurant/markets to produce animal feed. Are you working together with other companies to produce your product? If so, how do you work together with other companies in the value chain?	1 Yes; 2 No
	If so, how do you work together with other companies in the value chain?	
	If yes, what are the challenges in this form of collaboration?	
	Are there any formal or informal institutions that support you with the cooperation between different stakeholders of the value chain?	1 Yes; 2 No
	If yes, what kind of institutions?	*More than one answer is possible* 1 Government 2 Private 3 Non-Governmental organizations) 4 Local communities 5 consultant

		6 Others, such as
	If yes, how do they support you?	
Social/cultural	What keeps your clients committed to buying your products?	*More than one answer is possible* 1 Price 2 Quality 3 No other similar products on the market 4 Additional services 5 Other such as
	Did you face challenges to attract customers for your products?	1 Yes; 2 No
	What did you do to overcome these challenges?	
	Are there any cultural or customer behavioral challenges for buying your product? For instance, animal feed is made from the larvae of flies, the customer do not want to buy animal feed made from insects.	1 Yes; 2 No
	If yes, what are the challenges?	*More than one answer possible* 1 Social acceptance of your product 2 Environmental literacy of the customers 3 Different service model 4 Hyper consuming habits 5 Other such as

Source: author

In the next following table, please fill in the importance of each of the formulated barriers towards your company operations in order to use waste as input of your production, to reduce your waste, re-use your material in your production process, use of renewable energy and to recycle within your company. In order words, the importance of barriers that hinder the development towards circular business models and to close the loop of resources. Please fill in the next questions the importance of each formatted toward your company by marking the barriers from level 1 to 5. Five means highest important (great barrier), while grade one means low or not important. You have the opportunity to add comments/explanations by their ranking to explain why or why not the formulated barriers are important for their businesses. In the end, you will also have the opportunity to add other barriers that are not on the list.

Table 21. Questionnaire survey about the ranking of different barriers.

Code	Type of barrier	Importance of the barrier	Explanation
B1	Lack of appropriate technologies		
B2	Lack of skilled workers, technical support, training and knowledge		
B3	Previous decisions/investments in specialized knowledge-, technological skills and investments in technologies hinder the investment towards a more circular business model. For instance, for a farmer that is specialized in keeping pigs it does not have additional value to follow a training about biological farming with cattle.		
B4	Large capital requirements and high initial costs for establishing a circular economy model, for instance the high costs of technologies		
B5	Significant transaction costs (costs such as the finding and negotiations with customers and suppliers/policy and enforcement costs to ensure that the other party sticks to the contract) for establishing a circular economy business model		
B6	There is not enough/inadequate information available about the quality of circular economy product/service for the company and the customer		
B7	Uncertain market for a product/service with a circular economy business model		
B8	New circular economy business models that are not proven hamper investments		
B9	Insufficient public goods/infrastructure, for instance there is no formal waste collection system		
B10	Insufficient competition/markets for products/services with a circular business model		
B11	The company is depending on previous long-term investments by your company		
B12	Circular business models are depending on other companies in one integrated value chain, for example, an organic fertilizer/animal feed production is dependent on flexible inputs of organic waste delivered by restaurants/market.		
B13	Circular business models are not profitable		
B14	There is lack of adequate defined policy frameworks with clear defined targets, objects and incentives in policies towards companies with circular business model (waste, re-use/reduce of materials, recycling and the use of renewable resources).		
B15	Implementation & enforcement failures *of policies*		
B16	Unintended consequences of existing policies, for example food safety regulations prevent the use of organic waste as animal feed.		
B17	The government has a dominant focus on recycling in policies and regulations, and is not focused on policies and regulations towards waste, reduce and re-use of materials and renewable resources.		
B18	Changing governments with changing policies. For instance, the government promote the use organic fertilizer for 5 years - after the elections the government change the policies, the government promote the use of artificial fertilizers instead of organic fertilizers *		
B19	Lack of government investment capital/willing *for establishing circular economy*		
B20	Insufficient public goods/infrastructure, for instance there is no formal infrastructure for waste collection/ no formal infrastructure for recycling		
B21	Different *lifecycle* of products (long- and short term), for instance a customer does not buy animal feed made from insects, but only wants to buy animal feed from artificial animal feed.		
B22	Rigidity and path dependency of consumer behavior due business routines and environmental literacy		
B23	An economy that is based on planned hyper consumption, for instance to provide solar lights to farmers, but do not deliver parts to repair the solar lights		

Source: author

Which other barriers are important for your company but are not included in the list?

Why are these barriers important for your company?

In the next following table, please fill in the importance of each of the formulated government interventions towards your company by marking the level from 1 to 5. A five (5) means the highest important barrier (great barrier), while grade 1 means low or not important barrier. Respondents have the opportunity to add comments by their ranking to explain why or why not the formulated barriers are important for their businesses.

Table 22. Questionnaire survey about the ranking of different interventions.

	Type of government intervention	**Importance of the intervention**	**Explanation**
G1	Change educational systems (changes in educational curricula and manner of teaching) in order to train the next generation of students about circular economy principles, practices and to be creative problem solver		
G2	Training for professionals that are working in/related to agriculture about circular economy concept and circular agriculture practices		
G3	Facilitate academic research to develop and improve (new) technologies and business practices through research experiments locations (test sites) and research budgets		
G5	Establish collaboration platforms in order to share and develop knowledge and (technical) solutions, such as public-private partnerships between research institutions, universities, government and the private sector/ research & development programmes		
G6	Demonstrate best practices to companies, for instance showing new technologies		
G7	Establish pilot projects in an organization/company		
G8	Information campaign for companies about circular economy practices		
G9	Establish business support schemes for companies with a circular business model (like grants, subsidies, financial guarantees and capital injections)		
G10	Initiate industry collaboration platforms that have the purpose to develop cooperation in an industry where unused or residual resources of one company are used by another		
G11	Initiation of voluntary (environmental) industry initiatives, which are public-private efforts with intention to enhance environmental performance beyond existing legal binding policies and regulations. *For instance, establishing a voluntary and non-regulatory program that encourage corporations to install energy-efficient lighting technologies.*		
G12	Facilitate sector-working groups in order to identify circular opportunities for businesses and consumers		
G13	Business competitions with rewards to attract companies with a circular economy business model		
G14	Align circular economy ambitions and policies with stakeholders from the beginning		
G15	Introduce regulations to encourage circular activities/discourage non-circular activities		
G16	Introduce fiscal instruments that encourage circular business activities/discourage non-circular business activities		
G17	Reduce taxes on labour		
G18	Increase taxes on natural resources and pollution		
G19	Establish a national portal for circular economy business models (in the agriculture) that services as a national counter for finding solutions towards difficulties in regulations of circular economy practices and to inform the private sector about financial instruments for circular innovations.		
G20	Strategic roadmap with a coherent policy framework		
G21	The government initiate/encourage small wins that are small, concrete and simple steps that can become the steppingstones towards the transition of CE economy		
G22	The budgets of the public sector invest in circular economy activities		
G23	Improve waste collection and recycling by establishing a waste & recycling infrastructure		
G24	Awareness campaigns to the public and communities to inform them about the benefits of circular economy practices and products		
G25	Institutional- and regulatory framework with a common ambition towards a circular economy that includes all principles.		

Source: author

Which other government interventions are important for your company?

Why are these interventions important for your company?

*Voluntary industry initiatives 'are private/public efforts to enhance corporate environmental performance beyond the existing legal requirements' (Paton, 2000, p. 328). Paton stresses that voluntary initiatives can become an important factor in the mix of public policies and towards approaches for managing the industrial impact on the environment, however the efficiency might be uncertain compared to legal binding policy instruments.

Attachment 4. Overview informal sector – cassava value chain

Photo 1. The shop of an input supplier located around the market.

Photo 2. A farmer grows cassava and other crops.

Photo 3. A household of a farmer.

Photo 4. A farmer uses firewood for cooking.

Photo 5. Buckets and jerry cans are used to wash cassava.

Photo 6. Farmers peel cassava.

Photo 7. Traditional processor at work to process cassava into cassava flour. Farmers come to the milling facility to mill cassava into flour. Most of the processors are traditional processors.

Photo 8. A shop of traditional processor in a village. Jerry cans are recycled into scoops.

Photo 9. A collecting facility of a modern processor.

Photo 10. Cassava is collected from farmers and cassava is dried in the sun to prepare the cassava for processing (modern processor)

Photo 11. Cassava is washed in modern processing plant.

Photo 11. A shop of a retailer. A retailer sells the cassava flour, crops and other products to customers.

Attachment 5. Overview respondents with a formal company in East Africa

This attachment provides an overview of the different respondents that has contributed to this study. The names of respondents and companies are not included in respect of privacy.

Table 23. Overview background of the respondents of the 'formal sector'.

Timestamp	Country	Business activity	Category	Position respondent	Highest degree of completed education	business model
11/1/2019 15:32:11	Rwanda	Organic waste from the kitchen which is used for compost in our organic farm	horticulture	Director	Bachelor degree	in house circularity
11/2/2019 17:03:45	Rwanda	Making dumps side organic fertilizer; making biodiesel from seeds of avocado	compost/fertilizer	Managing director	Bachelor degree	circular (material mono flow cycle)
12/12/2019 16:04:42	Rwanda	creating value addition from orange sweet potatoes, producing products such as bread, biscuits, cakes	agribusiness	Co-founder and director	Bachelor degree	in house circularity
1/13/2020 16:26:30	Rwanda	The company was created to provide the most affordable and restorative organic fertilizer by leveraging on one of the most efficient and readily available resources: organic waste.	compost/fertilizer	Managing Director and co-founder	Master degree	circular (material mono flow cycle)
1/17/2020 16:28:20	Rwanda	We are producing sugar & Molasses (animal feed)	horticulture	General manager	Bachelor degree	in house circularity
1/19/2020 17:10:11	Rwanda	Organic farm producing free range chicken farm (egg & meat), turkey, goat and sheep's (meat)	livestock/poultry	Owner	Bachelor degree	partial integration
1/20/2020 17:31:49	Rwanda	Producing (processing) products such as sesame, tea leaves honey into oils, soaps (made from avocado), bee waste into oil and candles, export and import	agribusiness	Owner	High school	partial integration
1/21/2020 12:08:35	Rwanda	Fruits and vegetables such as strawberries, tomatoes & peppers	horticulture	CEO	Bachelor degree	in house circularity
1/21/2020 15:48:26	Rwanda	sanitation company specialized in waste collection & recycling	compost/fertilizer	General manager	Master degree	circular
1/23/2020 20:25:22	Rwanda	Producing salad by using aquaponics	horticulture	Owner	Bachelor degree	in house circularity
2/4/2020 15:20:01	**Rwanda,** Burundi, Kenya, Uganda, Zambia, Burkina Faso, Ghana, Benin	We are input supplier for hybrid seeds, pest & disease management products. We provide irrigation systems & greenhouses, and soil analysis. We are also providing training and establish demonstration farms with lead farmers in different districts.	Input supplier	Manager Rwanda & Burundi	Bachelor degree	non-circular
2/4/2020 19:02:59	Rwanda	Producing different kind of mushrooms and mushroom substrates for other growers	horticulture	Owner	Master degree	in house circularity
2/7/2020 12:09:57	Rwanda	Producing all different types of tea	horticulture	General manager	Bachelor degree	in house circularity
2/17/2020 16:49:35	Rwanda	Producing mineral water, juice and milk products	agribusiness / livestock	OEHS Manager	Bachelor degree	non-circular

2/26/2020 17:43:33	Rwanda	Producing animal and organic fertilizer through growing black soldier flies on waste	animal feed	CEO	Master degree	circular
12/19/2019 16:33:31	Kenya	Convert waste into organic fertilizer and insect-based animal feed	animal feed	Co-Founder	Master degree	circular
1/21/2020 10:56:25	Kenya	all our products are derived from insects. Our first product is the black soldier fly. This fly results in: protein for animal feed, fertilizer, Chitin	animal feed	CEO	Bachelor degree	circular
1/21/2020 23:32:17	Kenya	We help farmers have access to high quality affordable fertilizers	compost/fertilizer	CEO	Bachelor degree	circular
2/4/2020 9:27:36	Kenya	The company primarily grows and sells flowers	horticulture	Director - HR & Administration	Continuing on my Doctorate degree	in house circularity
1/6/2020 8:23:34	Tanzania	The company is providing different services towards recycling. On part of our company is focused to grow insects for high protein animal feed at household level and commercial level. At commercial level the company collect organic waste as input to grow insects (black soldier flees) for animal feed (chicken and fish feed). In addition, the company also sells dog feed to one shelter for dogs in Dar es Salaam. At household level the company sells bins to household in order to collect waste for animal feed by growing insects.	animal feed	Founder and Managing Director, co-founder of a second company	Master degree	circular
1/7/2020 11:43:25	Tanzania	Organic farm for producing fruits, vegetables, small stock (chicken, rabbit, goat, cows) for producing milk and meat	horticulture	Owner	Phd.	partial integration
1/7/2020 16:01:12	Tanzania	Avocado farm	horticulture	Project manager.	High school	non-circular
1/8/2020 9:49:54	Tanzania	The company is producing rice and rice seeds (input supplier)	horticulture	Co-owner	Master degree	in house circularity
1/15/2020 17:26:39	Tanzania	Compost fertilizers, protein feeds for chickens	other	Director	Bachelor degree	Other
1/16/2020 12:29:29	Tanzania	Among others, we import, market and distribute Biostimulant products from Agritecno Fertilizantes based in Spain, and Vegetable seeds from Syngenta, Netherlands.	Input supplier	Managing Director	Bachelor degree	Non-circular
1/23/2020 13:07:29	Tanzania	The company breeds new hybrid vegetable varieties for professional farmers. In Tanzania we demo in Centres of Excellence, train through PPP Sevia and sell seeds.	horticulture	Area Manager Africa (formerly 10 years MD Tanzania)	Master degree	in house circularity

Source: author

Attachments 6. Quantities of waste

This attachment provides an overview of the quantities waste that are produced by different actors of the 'informal sector'. Furthermore, it shows the quantities of waste that are dumped per actor.

Table 24. Overview of the average quantity generated waste per type per individual actor per week in kilogram – 'informal sector'.

	Input supplier	Farmer	Collector	Processor	Retailer
Average quantity liquid waste generated per person per week	0.0	21.1	420.0	366.4	6.0
Average quantity organic waste generated per person per week	2.5	136.9	378.0	352.7	21.5
Average quantity generated pesticides produced per person per week	0.0	0.0	0.0	0.0	0.0
Average quantity of generated plastic waste per person per week	0.6	0.5	0.0	0.0	0.0
Average quantity generated paper waste person per week	1.9	0.0	0.0	0.0	0.1

Source: author

Table 25. Overview of total generated and dumped waste per person per type of waste in kilogram per week – 'informal sector'.

	Input supplier	Farmer	Collector	Processor	Retailer
total dumped liquid waste in kg/per person / per week	0.0	0.0	210.0	33.3	0.0
total dumped organic waste in kg/per person / per week	0.0	18.5	37.8	0.0	9.2
total dumped plastic waste - pesticides in kg/per person	0.0	0.0	0.0	0.0	0.0
Total dumped plastic waste - in kg/per person/per week	1.8	1.9	0.0	0.0	0.1
Total dumped paper waste - in kg/per person/ per week	9.7	0.0	0.0	0.0	0.0

Source: author