MSc Program
Environmental Technology & International Affairs

Analysis of the current status of textile waste management in Tanzania and suggestions for improvement

A Master's Thesis submitted for the degree of
"Master of Science"

supervised by
Assoc.-Prof. Dipl-Ing. Dr.techn. Johann Fellner

Mag.iur. Agnieszka Maria Kuderer

00504056

Vienna, 20.06.2022

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.

Affidavit

I, **MAG.IUR. AGNIESZKA MARIA KUDERER**, hereby declare

1. that I am the sole author of the present Master's Thesis, "ANALYSIS OF THE CURRENT STATUS OF TEXTILE WASTE MANAGEMENT IN TANZANIA AND SUGGESTIONS FOR IMPROVEMENT", 80 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted the topic of this Master's Thesis or parts of it in any form for assessment as an examination paper, either in Austria or abroad.

Vienna, 20.06.2022

_____
Signature

I. Abstract

While the global textile apparel industry is one of the most potent economic actors worldwide and provides a livelihood for over 300 million people across the value chain, its negative environmental and social impacts undisputedly burden Earth's resources and future generations. Moreover, due to its highly globalised character, most of the pressures and impacts related to the consumption of textiles occur in other regions of the world than in which they are consumed by using up natural resources or contributing to increased waste generation (EEA, 2019). Driven by unsustainable production cycles and culture of overconsumption, the textile apparel industry lags in environmental indicators and collides with globally agreed-upon Sustainable Development Goals.

Textile apparel material waste and end-of-life textiles have recently come into the policy spotlight by endorsing circular approaches to make the textile apparel sector more sustainable. However, textile waste is still massively under-researched, particularly in low-income countries. Alongside the lack of awareness in this area, there is also a lack of data and targeted legislation and policy.

This study has identified pre-and post-consumer textile waste flows in the United Republic of Tanzania based on interviews with experts and small-scale surveys at secondhand markets and complemented by a literature review, legislation, and policy research.

The results have shown that reuse and repair options for textile waste best fit in the context of low-income countries. Given the capacity constraints concerning finance, technical and technological backup, the term recycling in the traditional sense must be adapted to the context of low-income countries, taking into account its potential and needs. A reinterpretation could include the term upcycling and thus create new uses for textile waste. However, there is a vast research scope in this domain.

By evaluating the current status of textile waste management in the United Republic of Tanzania, this Master's thesis contributes to understanding the overall framework of the textile waste value chain, trying to capture the potential of reuse and recycling options for textile waste. In addition, the results may serve as an orientation tool for future legislation and policy on textile waste in low-income countries.

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

II. Table of Contents

I. Abstract i
II. Table of Contents ii
III. List of Abbreviations iv
IV. Acknowledgements 6
1. Introduction 7
1.1. Hypothesis and Research Question 8
1.2. Thesis structure 9
2. Methods 10
2.1 Literature review 10
2.2. Primary research data collection techniques 10
2.2.1. Personal field observations 10
2.2.2. Small-scale survey 11
2.2.3. Expert Interviews 11
3. State of the Art 15
3.1. Textile types and output volumes 15
3.2. Textile consumption patterns and lifetime 16
3.3. Environmental and social aspects of textiles and textile wastes 18
3.4. Textile wastes and textile recycling 21
3.4.1. Textile waste from production 21
3.4.2. Textile waste from consumption 22
3.4.3. Textile recycling 23
3.5. Recycling possibilities, opportunities and limitations for textile waste management 27
4. Results and Discussion 34
4.1. The global textile value chain and fast fashion 34
4.1.1 Tanzanian textile industry and secondhand clothing trade 35
4.1.2. Secondhand clothing trade 37
4.2. Tanzanian legislation and policy on textile waste management 40
4.3. Tanzanian waste management system 44
4.3.1. Current practice in waste management 48
4.3.2. Textile waste management in Tanzania 50
4.3.3. Informal sector 58

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

4.4. Challenges in textile waste management 59
4.5. Mapping the potential for managing textile waste.....61
4.6. Limitations to the research topic.....65
5. Conclusion and outlook 67
Bibliography 69
List of Tables.....77
List of Figures.....78

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

III. List of Abbreviations

ACEA	African Circular Economy Alliance
ACT	Africa Collect Textiles
AGOA	African Growth and Opportunity Act
AMCEN	African Ministerial Conference on the Environment
CIRFS	Comité International de la Rayonne et des Fibres Synthétiques; European Man-Made Fibres Association
CBOs	Community-based organisation
DCC	Dar es Salaam City Council
EAC	East African Community
EEA	European Environment Agency
EIT	European Institute of Innovation and Technology
EMA	Environmental Management Act
EPA	Extended producer responsibility
EU	European Union
FAO/ICAC	Food and Agriculture Organization of the United Nations and International Cotton Advisory Committee
GAIA	Global Alliance for Incinerator Alternatives
GPN	Global Production Network
GSP	Generalised System of Preferences
ILO	International Labour Organisation
ISWA	International Solid Waste Association
MDGs	Millenium Development Goals
MeTL	Mohammed Enterprises Tanzania Limited
MFA	Multi Fibre Arrangement
NEMC	National Environment Management Council
NPEs	Nonylphenol ethoxylates
NSWMS	National Solid Waste Management Strategy Tanzania
OEC	Observatory of Economic Complexity
OECD	Organisation for Economic Co-operation and Development
PET	Polyethylene terephthalate

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

POPs	Persistent organic pollutants
RCC	Refuse Collection Charge
SDGs	Sustainable Development Goals
UBA	Umweltbundesamt
UN	United Nations
UN DESA	United Nations Department of Economic and Social Affairs
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organisation
UNITAR	United Nations Institute for Training and Research
US	United States
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNICEF	United Nations International Children's Emergency Fund
WCO	World Customs Organisation
WFD	Waste Framework Directive

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

IV. Acknowledgements

"Elimu haina mwisho"

(Kiswahili for "Learning has no end")

Let's learn from each other and shape the future of our global community for the better.

First, I would like to express my gratitude to my supervisor, Assoc.-Prof. Dipl-Ing. Dr.techn. Johann Fellner for his guidance throughout my thesis and for encouraging me to pursue a topic that I am passionate about. Second, special thanks go to ao.Univ.-Prof.i.R. Dipl.-Ing. Dr.techn. Hans Puxbaum, whose tireless efforts over the last two years have strengthened people's identification with the values of the ETIA program. I am also thankful to the selection committee for receiving the ETIA travel allowance. Without the support, many of the insights of this study would have remained hidden from me.

On a personal level, I would like to thank my daughter Maja Sophia for inspiring me to take a look at myself and make a change.

Lastly, I would like to thank my friends and family for being there for me, particularly my husband, Markus.

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

1. Introduction

"As colourful fashion can be, it is responsible for one of the most glaring environmental and social failures of our current economic system" (United Nations High Level Political Forum, 2021).

This statement at the highest political level highlights the detrimental environmental and social impacts of the textile apparel industry the world is currently facing. As a critical emitter of greenhouse gas emissions with an estimated 8 % of the world's emissions, the production of textiles massively contributes to climate change (Quantis, 2018). In addition, the poor social standards along the global fashion value chain, disproportionally affecting women, have been widely criticised. However, the industry is only projected to grow in the coming years (United Nations (UN) Fashion Alliance, 2022). While the current fibre production is estimated to be approximately 100 million tons per year, more than 73% of textiles produced worldwide are incinerated or landfilled (CIRFS, 2022; Ellen Mac Arthur Foundation, 2017). The latter number is equivalent to a garbage truck of textiles burned or landfilled every second (Ellen Mac Arthur Foundation, 2017).

Although basic human needs in some of the world's low-income and least developed countries are still not met, the global community is confronted with a massive increase in solid waste generation. One of its main contributors is the textile apparel industry, with the waste generated by producing and consuming textile goods. A newly observed trend is the relocation of manufacturing sites to African countries due to lower labour costs, resulting in an increased pre-consumer waste flow (Quantis, 2018). In addition, several studies have shown that textile waste quantities from the post-consumer side are increasing, a trend that is particularly noticeable in African low-income countries (Ellen MacArthur Foundation, 2017; McKinsey, 2016; McKinsey, 2016b; FAO/ICAC, 2013). At the same time, it was highlighted that secondhand clothing exports to African countries are significant and steadily growing (European Environment Agency (EEA), 2019).

The average citizen in a high-income country does not immediately notice rising textile waste because of a sophisticated waste management system or scheme for the collection of textiles. In contrast, augmenting textile waste in low-income countries means piles of waste in landfills or unregulated settings, posing an immediate health risk to human health and polluting the environment. Given the textile apparel sector's size and reach, future projections in expanding textile waste streams will challenge critical infrastructure and endanger human health, animals, and the environment in low-income countries if not efficiently and effectively handled.

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

This thesis examines the current status of textile waste management in the United Republic of Tanzania as a low-income country with a continuously increasing population and GDP. By determining the main contributors and drivers of textile waste from the pre- and post-consumer side, the potential of reuse and recycling options for textile waste shall be assessed.

1.1. Hypothesis and Research Question

The United Republic of Tanzania was home to nearly 60 million people in 2020 (The World Bank, 2021) and has a steadily growing population. It is also an attractive location for investors due to its abundant resources and low-wage labour. Therefore, an increase in the production capacity of the textile industry is visible (Tanzania Industrial Competitiveness Report, 2015). The population growth trend coupled with rising living standards and rapid development in the industrial sector has resulted in increased solid waste generation, mainly by industrial and post-consumer activities.

Given the urgent importance of a paradigm shift in production, consumption, and disposal of fashion items to avoid a deterioration of the environmental crisis and guarantee future generations' well-being, this thesis aims to examine the current status of textile waste management and the potential of reuse and recycling options for textile waste in Tanzania. Followingly, the research questions answered in this Master's thesis are:

Research Question 1: What is the current status of textile waste management in Tanzania?
The primary step in answering the first research question is to highlight the system behind textile waste management in Tanzania by analysing the legal and political framework concerning textile waste management. The second step will highlight the Tanzanian textile waste management system and practices. Consequently, potential gaps shall be determined, and the results obtained may serve as an orientation for implementing textile-related legislation or policy documents.

Research Question 2: What are the sources and pathways of textile waste in Tanzania?
The study seeks to address this question by determining the main contributors of textile waste in Tanzania and analysing the main drivers of growing textile waste streams. Small-scale surveys conducted at three markets in Dar es Salaam give insights into waste management practices from post-consumer activities at the market level.

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

Research Question 3: What is the potential of reuse and recycling options for textile waste in Tanzania?

Here, the aim is to assess the potential for various textile waste reuse and recycling routes and look into the informal sector. At the same time, challenges in textile waste management shall be highlighted. The multiple options for managing textile waste are discussed under the 3R principle of reducing, reusing and recycling along the waste hierarchy. The study contributes to knowledge sharing in the field of textile waste management and may enhance good practices.

1.2. Thesis structure

The structure of this Master's thesis is organised in the following manner: The methodological section explains the two research methods chosen. At first, the textile and apparel industry's central literature and theoretical background are discussed. In the next step, an exploratory approach with three primary data collection techniques is used to evaluate the state of the art in textile waste management in Tanzania. The last part discusses the results, research implications, and challenges and limitations. Finally, a conclusion and an outlook are given.

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

2. Methods

This Master's thesis combines qualitative and quantitative methods to evaluate the current status of Tanzania's textile waste management system and assess the potential of reuse and recycling options for textile waste. It relies on two complementary research methodologies in an effort to answer the research questions posed. A literature review was carried out (2.1.) to present the theoretical and technical background and overview of textiles and textile waste's environmental and social impacts. Other primary research data collection techniques (2.2.) included personal field observations, a small-scale survey, and semi-structured expert interviews to address limitations due to data scarcity. These research methods were crucial for comprehensively identifying the changes in flows and stocks and presenting information on Tanzania's sources, pathways, and sinks of textile waste.

2.1 Literature review

A comprehensive literature review was performed to identify the theoretical foundation for the research and establish the research focus. The main focus was on scientific journals, technical and working papers, legal databases, and Tanzanian and United Nations (UN) and European Union (EU) policy documents. In addition, official national websites and NGO reports were used. Reference was further made to media and press articles. All types of available published studies, peer-reviewed or not, were considered in the identified literature.

Generally, it can be argued that the research topic is under-researched, and there is a significant lack of data.

2.2. Primary research data collection techniques

Three primary data collection techniques were used to obtain data: personal field observations in the city of Dar es Salaam, a small-scale survey at the market level, and semi-structured expert interviews.

2.2.1. Personal field observations

Personal field observations in Dar es Salaam in January 2022 contributed to a comprehensive presentation of the textile waste value chain. Several districts have been explored (Ilala, Kigamboni, Kinondoni, Temeke) to get in-depth insights into waste

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU Bibliothek Your knowledge hub WIEN

management practices and the infrastructural circumstances as a prerequisite for waste management logistics. This first-hand information was essential to analyse the waste management system regarding the pre-collection or primary waste storage, the collection method, and the types of waste collection vehicles used in Dar es Salaam. In addition, these learning experiences provided valuable insights into standard textile waste management practices and limited awareness in this regard. They further helped to derive conclusions about their recycling potential. Photographs that illustrate this Master's thesis attempt to document standard practices in textile waste management and textile waste pollution in Dar es Salaam.

2.2.2. Small-scale survey

The small-scale survey was focused on markets in the city of Dar es Salaam in January 2022. The specific area of study included three secondhand markets (Ilala market, Kariakoo market and Manzese Tandale market) in the districts of Ilala and Kinondoni. To understand the factors affecting the state of textile waste management of secondhand imported clothing at the market level in Dar es Salaam, a number of sixteen secondhand vendors and four tailors were questioned in the form of a semi-structured interview.

The specific objectives of the survey were the following:

(1) To evaluate textile waste management from imported secondhand clothing as part of the post-consumer waste stream.
(2) To determine factors influencing the textile waste generation and collection and trends in Dar es Salaam.
(3) To learn about people's awareness regarding textile waste management and its importance for the city of Dar es Salaam and the environment at large.

2.2.3. Expert Interviews

Semi-structured expert interviews were chosen as a complementary means of data collection due to limited data on waste management in Tanzania (National Bureau of Statistics report, 2015). Five interviews with Tanzanian experts were conducted to overcome limitations with the management practices of textile waste in municipalities within the country and quantify the amount of textile waste. The remaining Austrian expert looked at the issue from the perspective of technology. When selecting potential interview partners, attention was paid to the complementarity of the experts. All interviewees had considerable expertise and many years of experience in waste

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU Bibliothek Your knowledge hub WIEN

management or textile waste management. To shed more light on the recycling potential, particular emphasis was placed on specialist knowledge in this area during the selection process. The interview partners were identified by their institutional affiliation, professional standing, or network. Since the current state of research on textile waste in Tanzania is still minimal, the network of experts in Tanzania was beneficial.

Initial contacts were made through various channels, mainly through e-mail correspondence and telephone calls. The research stay in Tanzania from the end of December 2021 until the beginning of January 2022 made it possible to establish important contacts in the region. The expert network and their project partners were also instrumental in establishing further connections. The first interviews were held in person at the beginning of January 2022 in the city of Dar es Salaam. Other discussions took place from March to May 2022 via remote video calls.

The following scheme applied to the interview questions asked:

(1) Introductory questions in the respective field opened the conversation. This part was adapted to each interviewee.
(2) The second question set was explicitly related to the experience of the experts with textile waste and the problems they encountered in dealing with it. The main objective of these questions was to evaluate the state of textile waste management and highlight recycling practices of textile waste. In a second step, existing gaps were identified.
(3) Finally, the experts were asked to define the main challenges in textile waste management and reflect on its potential.
(4) The last question referred to a future forecast of the experts, in the narrower sense, whether they expected changes in the field of textile waste management shortly.

A total of six experts were interviewed on the following topics:

(i) A representative of the Department for Chemical and Processing Engineering at the University of Dar es Salaam, referred to as the “Tanzanian engineering expert”, was interviewed in his role as a waste management expert and about the expertise he provided for Tanzania’s National Solid Waste Management Strategy (NSWMS 2018).

(ii) Founder and Director of a non-governmental organisation referred to as “Tanzanian non-governmental expert” was interviewed as a cross-sector

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

expert on sustainable development in waste management and pollution education.

(iii) An environmental entrepreneur, referred to as the "Tanzanian environmental entrepreneur expert", shared his view on textile waste management and recycling options for textile waste management.

(iv) A representative of a Tanzanian recycler association is referred to as a "Tanzanian recycling expert". This interview partner was chosen in his capacity as a recycling expert and shared his expertise on recycling options for textile waste management and the informal sector of the waste management system.

(v) An Environment Officer at the National Environment Management Council (NEMC) is referred to as a "Tanzanian environment expert". This stakeholder consultation offered the possibility of reviewing current solid waste management policies and their implementation. Tangible, solid waste management actions and their challenges were studied on a political level.

(vi) A technical expert referred to as the "Austrian fibre expert" covered the technical aspects of fibre and fibre recycling and shared his view on the circularity in textile recycling and recycling options in low-income countries.

Transcription of the audio recordings followed the interview stage. To analyse the transcript material, it had to be structured and arranged according to topics. Additional figures were sought in the publicly available literature and policy documents to supplement the interviews' statements and findings. The analysis of the interview transcripts was carried out according to the following aspects shown in Table 1:

Table 1: Analysis of the interview transcripts according to the following aspects

Textile apparel industry	Secondhand clothing trade	Tanzanian waste management system	Textile waste management
History/evolution as a priority sector	History	Waste management operations and practices	Pre-consumer/post-

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

			consumer waste streams
Production	Actors	Waste streams/composition	Quantity and composition
Consumer awareness	Competition	Legislation and policy on the state and local level	Awareness
Expected changes in the industry	Legislation and policy	Challenges	Challenges and recycling options
Recycling	Technology	Waste hierarchy	Circular economy
Collection services	Fibre technology	Prevention	Material components
Current practices	Textile types	Reuse	Design and processing
Informal sector	Technological progress	Recycling	Legislation and policy
Options for textile waste management	Limitations	Recovery	Extended Producer Responsibility (EPR)
		Disposal	Production and consumption

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

3. State of the Art

In this section, a literature review gives an overview of the following topics and provides relevant definitions in the textile context: Textile types and output volumes (3.1.), Textile consumption patterns and lifetime (3.2.), Environmental and social aspects of textiles and textile wastes (3.3.), Textile wastes and textile recycling (3.4.) and Recycling possibilities, opportunities, and limitations for textile waste management (3.5.).

3.1. Textile types and output volumes

The underlying component of woven fabrics or other textile structures is fibre. As defined by Houck (2009), a textile fibre is a *"unit of matter, either natural or manufactured".* It typically differs in chemical structure, cross-sectional shape, outside relief, colour, length, and width (Houck, 2009).

One can distinguish between natural and man-made fibres, including regenerated natural fibres such as lyocell, viscose or modal and synthetic fibres (Kolanjikombil, 2018). *"Any fibre that exists as such in the natural state"* can be defined as a natural fibre (Houck, 2009). This encloses materials such as cotton, wool or silk. Contrastingly, synthetic fibre does not occur naturally, and it is produced through a chemical process involving polymers. Examples of synthetic fibres are acrylic, nylon, polyethene, spandex or polyester (Kolanjikombil, 2018).

Fibre types nowadays represent augmenting complexity. The range extends from multi-material fibres or special fibres for high-performance, medical-technical innovations or smart fibres (Piribauer and Bartl, 2019). In addition to natural fibres such as hair and wool from animals and fibres from crops, the traditional textile industry works with natural polymers such as viscose fibres, synthetic polymers such as polyester and polyamide fibres, as well as inorganic fibres such as carbon and glass fibres (Piribauer and Bartl, 2019).

Global fibre production has experienced steady growth over the last decade and amounts to about 100 million tonnes per year (Ellen MacArthur Foundation, 2017; CIRFS, 2022). While cotton represents about 25 % of total fibre production, man-made fibres account for about 75 % - the latter with an output volume of around 76,5 million tonnes in 2019 (CIRFS, 2022). These fractions are visualised in Figure 1.

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

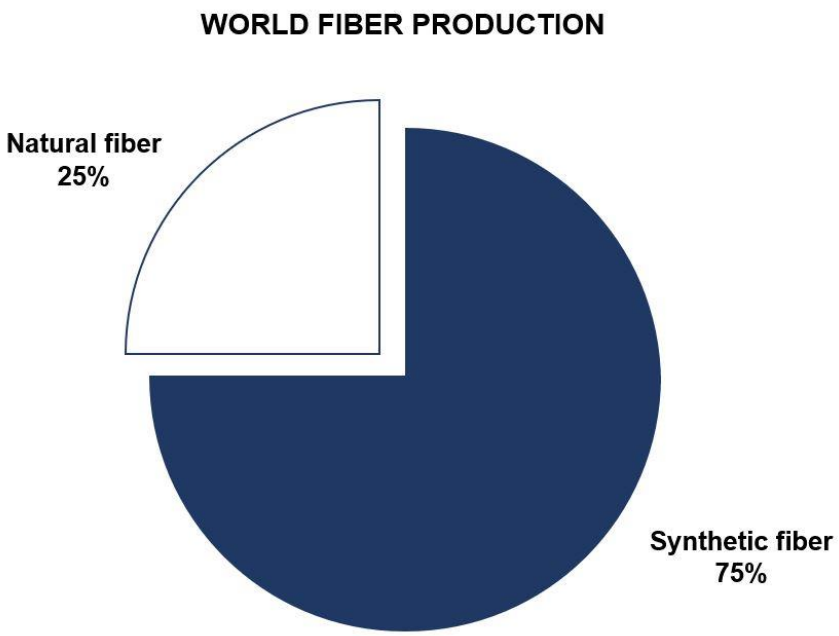

Figure 1: The total global volume output of fibre production is about 100 million tons per year. 75 % (76,5 million tons) represent man-made fibre types and 25 % (25 million tons) natural fibres, adapted after CIRFS (2022)

3.2. Textile consumption patterns and lifetime

The modern fashion industry is characterised by large production volumes, short product life cycles, low recycling and high rates of incineration and disposal (Piribauer & Bartl, 2019).

Strongly linked to economic growth, as it is dependent on the promotion of new products and the disposal of old ones, people today consume much more clothing on average than they did two decades ago (Koszewska, 2018). This is mainly driven by emerging markets, such as Asia and Africa, in which the per capita increase in textile consumption amounted to between 20 % (Africa) and 50 % (China) from the years 2004 to 2007 (Ellen MacArthur Foundation, 2017; FAO/ICAC, 2013). According to the European Environment Agency (2019), the EU produced on average 7,4 kilograms of textiles per capita while consuming around 26 kilograms per capita, making the EU market a net importer of textiles. This number includes all textile products from clothing and footwear to household textiles such as towels, curtains, bed linen, carpets, etc. Global synthetic and cotton fibre consumption increased from threshold amounts to over 60 million tons and from 10 million to 25 million tons (CIRFS, 2022).

In light of the recent Covid 19 pandemic, McKinsey's current State of Fashion report (2021) noted that by mid-2021, there was hope that the situation was taking a turn for the better, especially in markets with high vaccination rates. However, the United States'

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU Bibliothek Your knowledge hub WIEN

(US) reduction of pent-up demand peaks led to so-called *"revenge buying"*, which led to a growth spurt similar to an earlier phenomenon in China. With newfound freedom outside the home after almost two years, consumers increasingly turned to new clothing categories other than lounge and sportswear, resulting in more purchases (McKinsey, 2021).

In general, the life span of textiles is getting shorter. As defined by the Ellen MacArthur Foundation (2017), durability is "the number of times a garment is worn before it ceases to be used". Before disposal, the average lifespan of a garment has decreased by 36% between 2002 and 2016, while this figure is already 70% in China. (Ellen MacArthur Foundation, 2017; Zhang et al., 2016). This trend is likely to continue as emerging markets adapt to the West's low utilisation rate. Emerging economies, in particular, saw rising apparel sales due to the growth of the middle class in recent years (McKinsey, 2016). According to estimates by the authors of a McKinsey study (2016b), 80% of the population in emerging countries will reach the same level of clothing consumption as the Western world by 2025.

The decreasing durability of clothes is probably also due to their decreasing quality, a trend that can potentially be attributed to the expansion of fast fashion retailers. From a material point of view, that is tricky to argue because synthetics are generally very durable. From a manufacturing or garment-making point of view, it could be because there is a specific connection between the speed of production and quality, whether it is sewing threats or attaching buttons. Overall, fast fashion is deteriorating the quality because of the cheap production (Austrian fibre expert, personal communication, 20 May 2022). It is estimated that more than half of fast fashion produced is discarded in less than a year (McKinsey, 2016b). However, it should be noted that not only the reduced physical durability of garments or reduced use of clothing can cause this decline. The evolution may also reflect cultural differences in style, changing fashion trends or changes in body shape. But this decline can also be observed in products that are not so easily subject to the style change. For example, bedside articles saw a 50% decline in the EU in 15 years between 2002 and 2016, while the use of stockings declined by about 40% (Ellen MacArthur Foundation, 2017). Another factor that could play a role here is that younger people are increasingly unable to sew, and clothes are no longer repaired as they were in times of relative scarcity when the lifespan of materials spanned generations of families.

If relating the average lifespan of clothing to the environment, 400% more carbon emissions are produced when a garment is used five times instead of 50 times (Ellen

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

MacArthur Foundation, 2017). A further discussion of textiles' environmental and social impacts will follow in the next section.

3.3. Environmental and social aspects of textiles and textile wastes

The textile apparel industry is among the world's largest sectors, generates 2.4 trillion USD in revenue annually, and hires around 300 million people across the global value chain (UN Alliance for Sustainable Fashion, 2022). When considering which effect textiles have on our environment, firstly, one must consider their production, which affects global environmental pollution by taking a lot of energy and using up resources. In addition, due to limited or non-existent worker's rights, many workers face inhumane working conditions while heavily relying on the income from their job. The other most crucial aspect of the problem is the waste generated by producing and consuming textile goods. If solid waste is not being managed efficiently and effectively, it causes significant environmental pollution, adversely affecting human health, animals, biodiversity, and the environment.

The impacts of textiles and apparel production and consumption can be roughly divided into environmental and social.

According to the European Environment Agency (EEA) (2022a), textile consumption in Europe had the fourth-highest average environmental and climate change impact in 2020 when viewed from a global life cycle perspective. This trend must be analysed in a worldwide context as the textile value chain is a highly globalised one. According to a widely cited study, the global textile apparel and footwear industry combined account for an estimated 8 % of the world's greenhouse gas emissions (Quantis, 2018). The observed trend of relocating production sites from the Asian region to the African continent due to lower labour costs can further lead to a surge in greenhouse gas emissions if these new places' renewable energy forecasts do not support emission reduction opportunities for manufacturing (Quantis, 2018).

Another study by the EEA concluded that while the production and handling of the textile industry used approximately 1.3 tons of raw materials and 104 cubic meters of water per EU citizen in 2017, 85 % of the primary raw materials and 92 % of the water were used in other regions of the world (EEA, 2019). This confirms that textile and apparel production and consumption are highly globalised and suggests that the environmental impact is higher for poorer countries that rely on income from this industry. Since 785 million people do not have access to water, and as climate change progresses, these factors seem more important to consider (World Health Organisation, 2019).

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU Bibliothek Your knowledge hub WIEN

Although natural fibres like cotton are considered more environmentally friendly, cotton consumes vast amounts of water for its production. This has been widely studied. A study by the UNESCO Institute for Water Education (2005) has shown that the water footprint of cotton, defined as the *"total volume of freshwater that is used to produce the goods and services consumed by the inhabitants of the nation",* highly impacts the water systems of a country. The intensive use of pesticides or synthetic fertilisers and other agricultural products to grow this crop depletes the soil and destroys the soil's ability to regenerate itself. However, as illustrated in Figure 1, man-made fibres increasingly replace cotton, so synthetics are expected to overtake the apparel fibre market, and freshwater withdrawal is likely to be more moderate (Quantis, 2018). In addition, the overuse of chemicals in fibre production aggravates the disturbance of the water balance of the soil and leads to desertification and pollution. Another issue linked to soil degradation is deforestation for producing wood-based fibres like rayon, endangering the sensitive ecosystem and the livelihoods of indigenous communities (WWF, 2022).

Microfibre pollution understood as primary microplastics released into the oceans, constitutes a particular environmental concern. These pollutants stem primarily from oil-derived synthetic fibres like polyester, acrylic, or nylon (EEA, 2022b). According to the Ellen MacArthur Foundation (2017), the laundry of textiles releases about half a million tonnes of plastic microfibres into the ocean every year, causing harm to aquatic life. Suppose the growth trend of the textile industry continues. In that case, the accumulated weight of plastic microfibres entering the ocean between 2015 and 2050 is expected to be more than 22 million tonnes (Ellen MacArthur Foundation, 2017). A recent study demonstrated that microplastics from the environment ultimately end up in the human bloodstream. So far, it is unknown whether this potentially may affect human organs (Leslie & Lamoree, 2022). Moreover, washing new clothes releases hazardous chemicals into water bodies like rivers, lakes, and the sea. These include hormone-disrupting nonylphenol ethoxylates (NPEs) (Greenpeace, 2012).

The energy input for clothing production fibres varies significantly between the individual fibres, polyester, acrylic and nylon being the most intensive ones by taking up vast amounts of crude oil for their production.

Various social impacts can be linked to the textile industry. While it can be argued that local communities can benefit from employment in the industry, they may suffer from its poor environmental practices, such as discharged untreated wastewater polluting local rivers, which serve as a source for drinking, fishing, and bathing or toxic factory effluents (Ellen MacArthur Foundation, 2017). Not least because of the Rana Plaza tragedy in

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

Bangladesh in 2013, the industry is known for its inhumane working conditions, including dangerous practices, exposure to toxic substances, long working hours, minimum wages and the lack of regular contracts. However, minimum wages only cover a fraction of real living wages that a family would require to fulfil its basic needs. The European Parliament described some working conditions as slave labour (European Parliament, 2014).

Moreover, people working in the industry are not allowed to form unions, making it difficult for them to enforce their rights. Some reports highlight practices of child labour which constitutes a persistent problem globally. While child labour has declined in the last ten years in Asia and other parts of the world, a significant downward trend in the sub-Saharan region is notable, with more children working in that region than in the rest of the world combined (ILO & UNICEF, 2021). It has been acknowledged that women, in particular, are disproportionately affected by the impacts mentioned above (UN Alliance for Sustainable Fashion, 2022).

While the production of textiles primarily takes place in low-income countries, it is consumed in high-income countries to be shipped back to low-income countries as secondhand clothing. The majority of textile waste generated consists of synthetic fibre and is, therefore, non-biodegradable, resulting in piling up landfills.

The problems mentioned above related to the production and consumption of textiles have already reached the highest international political level. Fashion sector actors, public stakeholders and consumers have a crucial role in achieving the Sustainable Development Goals (SDGs), a set of the most important universal goals that have been agreed upon by the member states of the United Nations in 2015, following the conclusion of the Millenium Development Goals (MDGs). The 17 SDGs and their respective 169 targets were introduced in the 2030 Agenda for Sustainable Development and reflect the United Nations' objective to ensure international peace and security and promote friendly relations and cooperation among its members in solving global problems (United Nations, 1945). The two most relevant goals to highlight the issues associated with the topic of this thesis are SDG 12, aiming at responsible consumption and production patterns and SDG 15, which intends to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. SDG 12 is divided into eleven targets that deal with the conservation of resources, chemical waste, fossil fuels and the integration of sustainable practices into production cycles. SDG 15 has 12 targets in the domain of forestry, biodiversity, and ecosystems. The Member States have acknowledged that *"changes in consumption and production*

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

patterns can help to promote the decoupling of economic growth and human well-being from resource use and environmental impact" and that halting biodiversity loss and the ongoing degradation of the ecosystem will have positive impacts on human well-being and survival (UN DESA, 2022). SDG target 12.5, which is most pertinent to this thesis, mainly emphasises the importance of waste generation and management to ensure sustainable practices and aims to substantially reduce waste generation through prevention, reduction, reuse and recycling by 2030.

3.4. Textile wastes and textile recycling

The production and consumption of clothing generate a significant volume of waste. Firstly, it is necessary to identify and analyse the pre-consumer waste generated during production. It includes scraps from the textile industry, for example, cotton lint and damaged yarn and garbage from the apparel industry such as excess production or rejected apparel. A more detailed description of pre-consumer waste from textile apparel production can be found in Table 2. The post-consumer textile waste must be traced in a second step, including the waste from imported secondhand clothing.

3.4.1. Textile waste from production

The production phase involves various processes from spinning to knitting or weaving to dyeing, apparel making and finishing (Koszewska, 2019). In the following, the specific operations are described in more detail (Kabir et al., 2019; Khan and Islam, 2015; Nayak et al., 2019):

(1) Fibre production – it includes both natural (cotton, wool, silk, hemp, etc.) and synthetic fibres (lyocell, viscose, polyester, nylon, acrylic, etc. - for a detailed description, see (3.2.))
(2) Yarn production – a ring or rotor spinning mechanism processes cotton into yarns, whereas a melt or dry or wet spinning mechanism is used for synthetic fibres.
(3) Fabric production - knitted and woven fabrics are applied primarily for garment manufacturing.
(4) Wet processing – it includes dyeing, printing, washing, and finishing in every kind of fibres, yarns, fabrics, and garments. There is also material waste from the wet processing stage (Pensupa et al., 2017).
(5) Clothing production - Fabricating finished fabrics into garments in garment manufacturing plants, comprising cutting, pattern making, sewing, and finishing.

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU Bibliothek Your knowledge hub WIEN

Characterised by the high consumption of various resources in a long process sequence, the textile-apparel manufacturing process, from fabric production to dyeing and finishing techniques to clothing production, generates a significant amount of waste (Karthik & Gopalakrishnan, 2014). The waste generated in the production phase during the operations (2) - (5) includes fibres, yarns, fabrics and garments and can reach up to 25-40 %, whereby smaller manufacturing companies produce the more prominent part due to lower efficiency (Aus et al., 2021). Table 2 presents an overview of the production waste.

Table 2: Production waste generated during textile-apparel manufacturing, adapted after Akter et al. (2022)

Industry	Waste from the textile industry	Waste from the apparel industry
Spinning	Cotton lint, damaged yarn, unfinished coones	
Knitting/weaving	fly fibre, scrap yarn, greige/unfinished fabrics,	
Wet processing	rejected coloured fabrics, excess finished materials,	
Apparel	cutting waste	cutting waste, excess samples, excess production, defective clothing, rejected apparel, cancelled shipment products

The substances from solid waste from textile production can be recycled into new raw materials, and they can decompose in nature as they contain biodegradable materials such as fibres, yarns, and fabric scraps (Akter et al., 2022). In comparison, the solid wastes from the apparel industry as a mixture of both natural and synthetic fibres or other substances such as acrylic, wooden, or shell buttons, metallic zippers or metallic pushbuttons are difficult to degrade (Akter et al., 2022).

3.4.2. Textile waste from consumption

Post-consumer textile waste refers to end-of-life textiles, including reusable clothing and textile waste. It is generated after consumption by households, individuals and small

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU Bibliothek Your knowledge hub WIEN

businesses. The share of textile waste in the public waste stream has steadily increased over the last decade in industrialised countries and Tanzania (Environmental Protection Agency (EPA), 2018; National Solid Waste Management Strategy (NSWMS) Tanzania, 2018). Including products such as clothing, footwear, and fashion accessories, it has been identified as one of the primary sources of post-consumer municipal solid waste. Between 2004 and 2012, post-consumer textile waste significantly increased in the UK, with 4 to 19 kilograms per capita, Germany with 2 to 4 kilograms and Austria with 4 to 5 kilograms. According to the EEA (2019), the average textile waste flow from the post-consumer side lies at about 11 kg per capita per year, while at the same time, the export of secondhand clothing to Eastern European countries, Asia and Africa is significantly increasing. A more detailed presentation of the secondhand clothing trade will be given in section (4.1.1.).

There is no doubt that high-income countries contribute much more to the textile waste problem than low-income countries. However, if clothing consumption levels adjust, estimated to occur by 2025, low-income countries will face increased environmental challenges (McKinsey, 2016b).

3.4.3. Textile recycling

Conventionally, textile waste recycling refers to the mechanical or chemical reprocessing of pre-consumer and post-consumer textile wastes for use in new textile and non-textile products (Sandin & Peters, 2018). Estimates assume that globally, only about 1 % of clothes are recycled as clothing (European Parliament, 2022). While globally, the separate collection rate for end-of-life textiles varies widely, ranging from 23 % in Austria to 75 % in Germany within the EU, there is no separate collection system for used clothing in Tanzania (Umweltbundesamt (UBA), 2022; Fachverband Textilrecycling, 2020). The remaining share of textile waste from households, or in the case of Tanzania, the entire proportion, is disposed of in the form of mixed solid waste and eventually incinerated in the case of Austria and either landfilled or dumped in the case of Tanzania. High collection rates are no guarantee of environmentally sound management or recycling of textile waste. Much of the collected clothing is exported to countries that do not have a collection infrastructure, where it ends up being put into lower-value applications or ends up in landfills or dumped (Ellen MacArthur Foundation, 2017). A detailed review of the secondhand clothing trade in Tanzania will be given in the Results and Discussion section (4.1.1.). However, due to the increasing consumption of textiles and the associated generation of textile waste on the African continent, awareness of textile waste is growing in the East African region. Kenya, for example, successfully

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU Bibliothek Your knowledge hub WIEN

introduced a model for the collection and processing of used textiles in its capital Nairobi in 2013 (Kasper & Stroomer, 2021). Figure 2 shows global material flows for clothing in 2015, as depicted by the Allen MacArthur Foundation (2017).

Global material flows for clothing in 2015

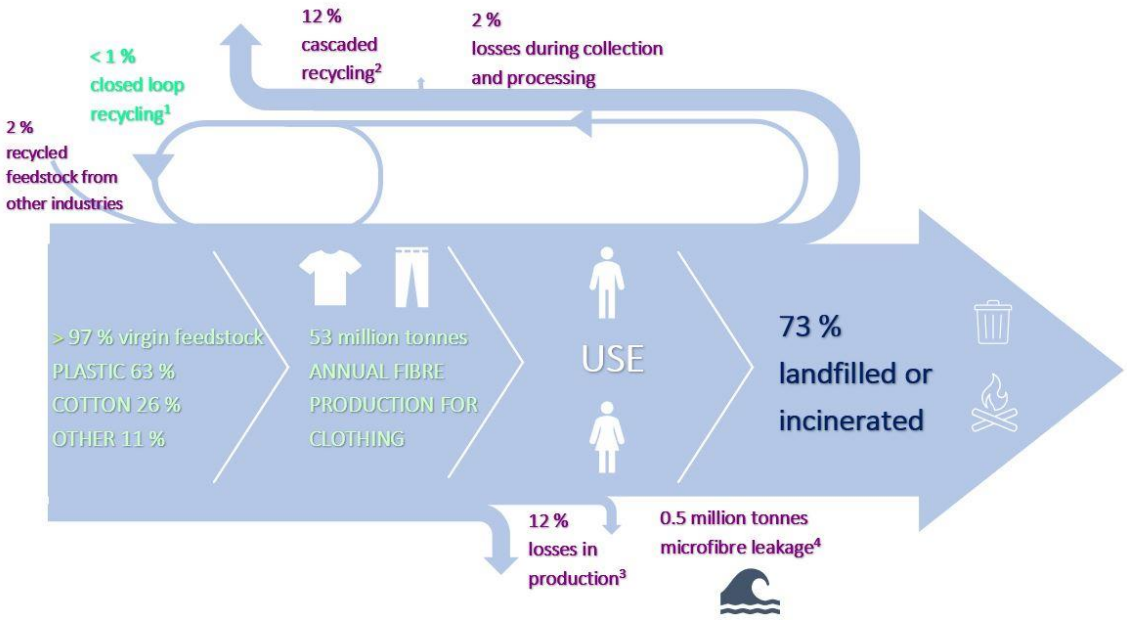

Figure 2: Diagram of global material flows for clothing in 2015, as depicted by Ellen MacArthur Foundation (2017), in which the common recycling routes and their losses can be retracted. While only 1 % is recycled into similar applications, 73 % of textiles are landfilled or incinerated. Adapted by author.

[1] Recycling of clothing into the same or similar quality applications
[2] Recycling of clothing into other, lower-value applications such as insulation material, wiping cloths, or mattress stuffing
[3] Includes factory offcuts and overstock liquidation
[4] Plastic microfibres shed through the washing of all textiles released into the ocean

Another recycling classification encloses the terms ‘downcycling’ and ‘upcycling’. The former refers to a recycled material or product of lower value than the original product. In contrast, the latter refers to a higher quality product or value than the actual product. A downcycled product typically includes industrial rags, substandard blankets, insulation materials and upholstery (Sandin & Peters, 2018). Table 3 illustrates a systematisation of recycling routes, as presented by the Ellen MacArthur Foundation (2017).

Table 3: Recycling routes, adapted from the report ‘A New Textiles Economy’ (Ellen MacArthur Foundation, 2017)

	Fabric recycling takes pieces of complete fabric that are resewed to create a new item. Commonly, this level of recycling is also referred to as “remanufacturing”. It uses manufacturing offcuts and leftover materials or significant parts of already used

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU Bibliothek Your knowledge hub WIEN

Fabric recycling	clothing. In this sense, the fabric is kept intact. Dying or bleaching processes can be applied if a colour change is needed. The advantage of fabric recycling is that it does not require advanced technologies. However, it has only limited applications because it is labour intensive. The inconsistent supply of fabrics does not allow for widescale production. The fabrics are usually too small to convert into another garment. In addition, the quality of the materials can be too low.
Yarn recycling	Yarn recycling is the unravelling of the yarns used in knitted garments. The challenge here is that it must be incorporated in a way that makes it possible to unravel the garment and get the yarn back. Yarn recycling is, therefore, only viable for specific types of garments. In addition, garments need to be collected separately or separated.
Fibre recycling	Fibre recycling refers to the process of shredding garments and converting them back into fibres. Garments need to be sorted by colour and material for this to happen. This level of recycling is known as “mechanical recycling”. The shredding process shortens the fibres, thus deteriorating in quality. This quality loss requires the use of higher-quality fibres. Current solutions regularly use virgin cotton or polyester recycled from Polyethylene terephthalate (PET) bottles as supplement material for creating new yarn. This process cannot separate blends or filter out dyes and contaminants by design. The associated problem with this technique concerns the occurrence of substances retained in the textiles. The recycling process can lead to the continued circulation of substances of concern. Currently, there are textiles on the market with higher amounts of specific substances than legally allowed because they were placed on the market before current regulations. No bleaching or dyeing processes must be applied if the garments are sorted by colour.
Polymer recycling	Polymer recycling refers to taking fibres back to the polymer level. The fibres are destroyed, but the material’s chemical structure is kept intact. Two variants are different in process and output quality: • Mechanical polymer recycling: This method is carried out via the melting and extruding of textiles made from one material, synthetic-based fibres. By design, this process does not allow for filtering out dyes and contaminants, like substances of concern. Similarly to fibre recycling, bleaching and redyeing are not needed; however, it is possible if a different colour is wanted. • Chemical polymer recycling: Textiles are dissolved with chemicals after the buttons and zippers are removed from the garments, and in some cases, the material needs to be de-coloured. This technology applies to plastic and cellulose-based fibres or a mix of both. Cellulose, the principal polymer component of cotton and polyester, is separated and extruded for further treatment. Cellulose pulp is then transformed into new cellulose-based fibres. The plastic polymers are treated individually to return them to the quality of virgin fibres. During

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

	the process, dyes, non-target fibres in small amounts and other impurities can be removed.
Chemical monomer recycling	This process breaks down polymers into individual monomers or other constituent materials. These materials can serve as feedstock for the production of virgin-quality polymers. Dyes, non-target fibres in small quantities, and other contaminants can be removed within the recycling process.

Scholars agree that current waste management practices represent overall downcycling. Sandin and Peters (2018) have critically noted, however, that downcycling is “not necessarily less preferable from a waste hierarchy perspective compared to polymer, oligomer or monomer recycling” because once the fibre length has been reduced to the point where the material is no longer suitable for textile or fibre recycling, it is sent for polymer, oligomer or monomer recycling. This is also consistent with the findings of Piribauer and Bartl (2018). They confirm that cutting up textiles to use as cleaning rags is a possible recycling operation if preparation for re-use or repair is not economically feasible.

Although textiles represent a resource-intensive and high-impact sector, textiles recycling is still an insignificant waste management practice, and the industry relies on inputs from virgin materials. The Austrian fibre expert confirmed this: Only about 8% of polyester fibre production is obtained from recycled polyester materials. While the ‘fibre-to-fibre’ process is still not very common today and comprises less than 1%, the ‘bottle-to-fibre’ process is common practice for polyester bottles. Most recycled polyester fibres are currently obtained from mechanically recycled PET bottles, making up around 15% (Austrian fibre expert, personal communication, 20 May 2022). On the one hand, this can be attributed to the linear nature of the current fashion and textiles industry. On the other hand, there are several technical limitations.

Technical constraints limit the recycling routes of textiles. The limitation of textile recycling is based on the individuality of materials in general. First, this refers to design, colour or patterns, and second, fibre mixes represent a significant challenge in textile recycling. This combination makes it difficult to separate the individual polymers. For example, elasthan, which is found in small quantities but often in textiles, is the most contaminating element and challenging to extract from a technological recycling point of view (Austrian fibre expert, personal communication, 20 May 2022). The processing of multi-material fabrics is often not economically feasible or even not possible with the

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

currently available technologies. As shown earlier in Table 3, the recycling routes mainly refer to textiles made from a single fibre material. However, to follow the circular economy approach, textile recycling should be done in a way *"that new fibre material with similar properties as the original material can be produced"* (Piribauer & Bartl, 2018). This approach is still a challenge in multi-material textiles, so design improvements and research and development in this area are essential (Piribauer & Bartl, 2018). However, research and development are working on the so-called technological readiness level on the lower side. Hence, it will take some time to climb up the leather and realise complex questions (Austrian fibre expert, personal communication, 20 May 2022).

While more and more efforts are being made in high-income countries to find ways to reuse, recycle and recover waste materials and to move towards a circular economy approach to textile waste, studies on waste generation and management of textile and apparel production in low-income countries such as Tanzania, seem to be still very limited. However, these would be necessary to promote environmentally friendly production and consumption and contribute to achieving Sustainable Development Goal (SDG) 12.

3.5. Recycling possibilities, opportunities and limitations for textile waste management

As outlined in section 3.4, textile waste recycling typically involves the mechanical or chemical reprocessing of textile waste for use in new textile and non-textile products. However, while current textile waste management practices represent extensive downcycling, there are also several technical limitations to textile recycling. Therefore, state of the art and the literature suggest that a conceptual pathway via the circular economy model for textiles and textile waste should be chosen. This is also in line with the waste hierarchy perspective. The circular economy model is primarily recognised by the industry and academia and is receiving increasing attention from stakeholders in the fashion and textile industry, both theoretically and practically (Akter et al., 2022). Thus, while the circular economy model offers possibilities and opportunities for businesses and consumers, specific challenges and limitations must also be considered.

Contrary to the current linear model, characterised by a ‘take-make-dispose’ sequence, the circular economy model aims to close material loops by incorporating recycling aspects. This requires the textile sector to pay more attention to the textile collection and recycling aspects. In addition to substituting primary materials with high-quality secondary materials, the entire value chain should be considered, and losses in the form

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

of waste and stocks reduced. Material losses occur at all stages of a product's life cycle. In addition to material losses, the time factor should also be considered, as resource stocks will convert to waste in the future (Ellen MacArthur Foundation, 2022). Therefore, considering material losses and the time factor increases autonomy and resource efficiency in a circular economy model (EIT Raw Materials, 2022). A schematic representation in Figure 3 visualises the circular economy model.

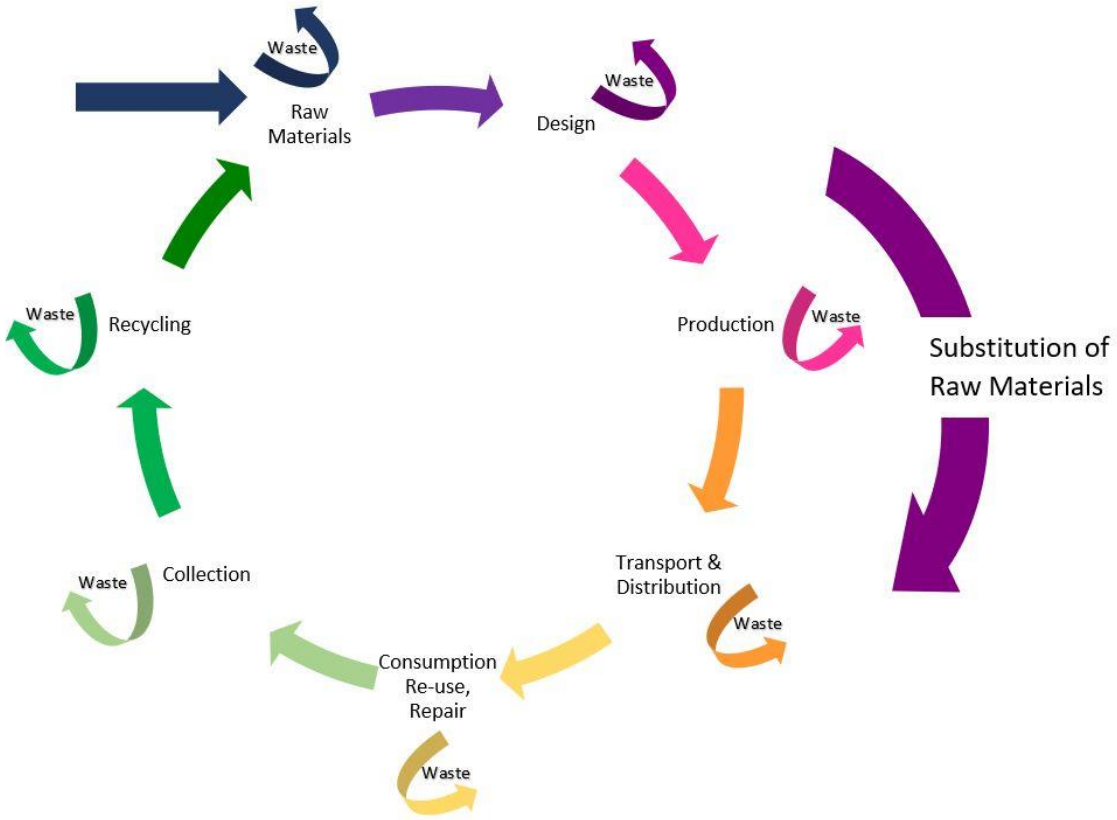

Figure 3: Schematic representation of the circular economy model, which strongly contrasts the linear 'take-make-dispose' system. The circular economy model aims to close material loops by integrating recycling aspects. This requires the textile sector to give more consideration to the collection of textiles and the recycling aspects. In addition to substituting primary materials with high-quality secondary materials, the entire value chain should be considered, and losses in the form of waste and stocks reduced. This increases autonomy and resource efficiency. Drawn after EIT Raw Materials (2022).

Sustainable production and waste management of textiles are becoming increasingly important in a circular economy approach. In this respect, traceability is seen as a growing strategic component as it helps track products, materials, and features and assesses socio-environmental conditions. In this way, waste and pollution can be avoided first, and the recyclability of products and materials can be improved (Ellen MacArthur Foundation, 2022). The goal is to create a viable and sustainable model while

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

minimising the use of resources and the generation of waste. One of the priority product groups is textiles, so the EU has launched a *Sustainable and Circular Textiles Strategy* on the European level. This strategy aims to ensure that by 2030 textile products placed on the market in the EU are durable, recyclable, made as much as possible from recycled fibres, free from hazardous substances and produced with respect for social rights and the environment. This will include measures on ecodesign requirements for textiles, a digital product passport and a legally binding EU extended producer responsibility (EPR) scheme (European Commission, 2022a). However, due to the highly globalised textile value chain, it is unclear how the EU will address this issue because the vast majority of textiles consumed in the EU come from external markets, particularly in Asia.

The following paragraphs discuss the current possibilities and opportunities and the limitations of managing textile waste along the waste hierarchy.

Prevention. A circular economy approach in the production phase should include a reduction of inventories, starting with the conscious selection of the number of raw materials. Akter et al. (2022) suggest a systematic observation of the market and demand and the simultaneous application of data processing methods. In this way, demand forecasting models could be created. Advanced optimisation techniques (combinatorial optimisation) could reduce waste in textile production, such as cutting scrap. This could be implemented through automated cutting machines supported by CAD programmes (Akter et al., 2022).

In addition, Akter et al. (2022) have emphasised that traceability of production waste is essential for optimal utilisation, which could be achieved through cooperation between producers, buyers, authorities, consumers and practitioners. In this regard, incentives for data sharing can be created through legislation, which will ultimately benefit the textile industry.

Furthermore, resource efficiency and autonomy in the production phase can be improved through restorative and regenerative product designs that aim to optimise the use and reuse of resources (Ellen MacArthur Foundation, 2017). When analysing the described challenges for recycling textiles in section 3.4., it also becomes clear that the design of the products must become more straightforward. This is also in line with the EU's current *European Green Deal* proposal for a *Regulation on Ecodesign for Sustainable products*, which aims to improve durability, reliability, reusability, upgradeability, repairability, recyclability, and energy and resource efficiency for products (European Commission, 2022a). Last but not least, the current health and geopolitical crises, namely the Covid 19 pandemic and Russia's invasion of Ukraine, have led to assumptions being

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

challenged and forced world leaders to rethink the current economic model and redesign the energy system. Therefore, a new approach to the way products are designed, produced and used is urgently needed (European Commission, 2022b).

As far as the prevention stage is concerned, increasing the rate of textile use, in other words, the number of times a garment can be used or worn, leads to waste being avoided in the first place (Ellen MacArthur Foundation, 2017). This was supported and stressed by all interview partners in this study (Tanzanian engineering expert, personal communication 3 January 2022; Tanzanian non-governmental expert, personal communication, 22 January 2022; Tanzanian environmental entrepreneur expert, personal communication, 30 March 2022; Tanzanian environment expert, personal communication, 17 May 2022; Tanzanian recycling expert, 19 May 2022; Austrian fibre expert, personal communication, 20 May 2022). A Eurobarometer survey conducted by the European Commission in 2020 found that 88% of EU citizens agree that clothing should be designed to last longer. While the desire for high-quality clothing is understandable, about half of all respondents (49%) say clothing should be available at the lowest possible price, regardless of socio-environmental impacts (EC, 2020). These two statements, which are ultimately challenging to reconcile, further confirm the trend toward fast fashion with its detrimental environmental and social impacts. Another point worth considering is the current quality of many textile items and garments, which would be necessary for a longer lifetime of textiles. As mentioned earlier, there is a specific connection between the speed of production and the quality of items produced, implying a deteriorating effect of fast fashion on textiles.

As far as emission reduction is concerned, a widely cited study has highlighted that circular economy measures form a viable pathway for materials reduction but do not affect an industry-wide emission reduction by more than 10% (Quantis, 2018). Therefore, a greater focus shall be placed on energy efficiency measures and increasing renewable energy.

Use. Introducing new sales and service models in the use phase of textiles could help minimise waste and stock throughout the value chain. Cooperative consumption models could extend the intensity of use. This represents a viable option for clothes that are not often or only used for a specific period, such as baby's clothes, luxury dresses and suits, or pregnancy clothing. Another way to extend the useful life of textile products is to provide adequate maintenance and repair services. These services should be economically profitable and widely available (European Commission, 2022b).

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

The EU Commission acknowledges considerable potential to reduce textile waste and boost its preparation for reuse and recycling. The EPR scheme forces producers to take legal responsibility for their products along the value chain, including when they become waste and could offer an effective measure to decouple textile waste generation from the sector's growth. Therefore, harmonised EPR rules for textiles with eco-modulation fees are proposed in the Waste Framework Directive revision in 2023 (European Commission, 2022a; European Commission, 2022b).

Generally, a global surge in EPR efforts can be noted. The Organisation for Economic Co-operation and Development (OECD) defines the EPR as an *"environmental policy approach in which a producer's responsibility of a product is extended to the post-consumer stage of a product's life cycle"* (OECD, 2016). The instrument can foresee different instruments such as (i) product take back, (ii) economic and market-based instruments including deposit-refund system, taxes on materials and a combined system of tax and subsidy, (iii) regulations and performance standards and (iv) information-based instruments (OECD, 2016). Ideally, this policy should involve the producer in collecting end-of-life textiles and their definitive treatment. It is, therefore, following the polluter-pays principle recognised in international environmental law. By increasing recycling rates, the overall waste destined for disposal is reduced (OECD, 2016). However, the feasibility of an EPR scheme for textiles still raises many questions, especially regarding who collects the materials, sorts them, recycles them, and monitors this process to ensure that the same rules apply to all those involved? (Austrian fibre expert, personal communication, 20 May 2022).

In recent years, textile apparel waste has come under greater scrutiny for its recycling potential. While researchers in high-income countries focus on the possibilities of efficient and cost-effective reuse, recovery and recycling of waste materials, the literature shows that, in contrast, there is a gap in research on textile apparel solid waste in low-income countries (Akter et al., 2022).

Recycling. As discussed above in section (3.4.) and the introductory part of this section, textile recycling is still a challenge nowadays. To summarise the findings, it can be generally stated that the more complex a material mix is, the more difficult it becomes to recycle. In addition, there are not enough options and incentives for economically feasible recycling of textile waste. In this regard, design improvement and research and development are vital to reaching the goal of a fibre-to-fibre process on a wide scale.

Energy recovery and final disposal. When waste prevention, reuse, and recycling options are exhausted or not applicable, textile waste must be disposed of. Therefore, the final

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

destination for most textiles is incineration or landfill. As shown in Figure 2, more than 73% of textiles produced worldwide are incinerated or landfilled (Ellen Mac Arthur Foundation, 2017). This has far-reaching consequences for the environment, as components initially incorporated into the materials during production and consumption are released into the environment. A study carried out by Greenpeace in 2012 investigated the presence of chemical residues within textile products or as residues remaining from use within manufacturing processes in 141 items of clothing purchased in 29 countries and regions (Greenpeace, 2012). They found NPEs in 89 of the purchased clothing items, high levels of toxic phthalates in four of the clothes, and cancer-causing amines in two of them. In addition, potentially hazardous industrial chemicals were discovered in various products tested (Greenpeace, 2012). In the EU, the degradation of textiles in landfills releases more than 2 000 tons of hazardous pigments each year (Swedish Chemicals Agency, 2014). This number is likely to grow with increasing textile waste in landfills. The Ellen MacArthur Foundation (2017) estimates that more than 150 million tonnes of clothing will be landfilled or burned in 2050 if a business-as-usual scenario continues. When considering the thermal treatment of textile waste, the incineration process can release substances of concern when incinerated without controlling emissions (Ellen MacArthur Foundation, 2017). However, it is a more favourable option than landfilling.

While around 30 % of textile waste is incinerated within the EU, landfilling presents the only option for textile waste in low-income countries. As recycling technologies are very costly and the facilities are not easily accessible, especially for low-income countries, they are more affected by the textile waste problem.

Limitations. The technical rules of recycling, which are laid down in sections (3.4.) and this section, must be considered when discussing the circular economy model. To summarise the findings, the current approaches to textile recycling are limited by the complexity of the materials, economic feasibility and generally, the energy input required.

However, the circular economy model also offers fundamental limitations in a socio-political context, as production and consumption patterns would have to change drastically (Koszewska, 2018). This requires profound social and political changes. However, such processes can be slow and long-lasting. Policy efforts and legislation in this regard can show a strong signal effect. They can create the necessary framework conditions to support a shift to sustainable production and consumption. Taxation of industries and improvement of working conditions and social rights of people who rely on the wages from the fashion industry is key to tackling the problem inclusively.

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

However, above all, a more conscious approach to consumption is required. Most relevant in this context is smart consumption, understood as the use of products and services that have the least possible impact on the environment. By simply reducing consumption, stress on the environment is alleviated, and less waste is produced. In this sense, a positive change towards more fairness and resource conservation can be achieved. Disruptive elements such as the current Covid-19 pandemic and the Ukraine crisis can accelerate such developments; however, it is difficult to anticipate whether they will have a sustainable impact.

Moreover, it must be critically noted that implementing the circular economy model alone will not have a lasting effect on the sustainability of the textile apparel sector in the long term. Therefore, different improvement measures such as the shift to renewable energy, higher energy efficiency as well as smart approaches for fibre and fabric recycling must be applied to comply with science-based targets (reducing greenhouse gas emissions by 80% by 2050 for an alignment of below two degrees celsius) and planetary boundaries, as highlighted by a frequently cited study (Quantis, 2018).

This section summarised the theoretical and technical fundamentals in the textile context. The following section brings up this thesis's Results and Discussion part (4.). After giving a deeper insight into the global textile value chain, the legal and political framework for textile waste management shall be highlighted. Eventually, the results obtained have implications for current practices in waste management and textile waste in particular. After assessing challenges in textile waste management and looking into the informal sector, the section discusses the various options for managing textile waste under the 3R principle of reducing, reusing and recycling along the waste hierarchy. Finally, further limitations to the study topic are outlined.

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

4. Results and Discussion

4.1. The global textile value chain and fast fashion

All stages of the textile value chain are highly globalised, making it the rare exception that a garment is produced in a single country (Austrian fibre expert, personal communication, 20 May 2022). When analysed in a historical context, the repeal of the Multi-Fibre Arrangement (MFA) in 2005 promoted the internationality of the textile value chain. The MFA regulated the textile quotas that low-income countries could export to high-income countries. In 2005, the International Labour Organisation (ILO) paper argued that the end of the MFA would change international trade tremendously and restructure the global sector, resulting in significant employment shifts within and between countries (ILO, 2005). The study forecasted the leading position of China in textile and clothing production and, generally, the high trade performance of South and South East Asia (ILO, 2005). Currently, China, followed by the European Union, covers around 30% of the textile and 70% of the clothing production (World Trade Organisation (WTO), 2021).

While the primary production of textiles and apparel stems from the Asian market, the principal reuse of clothing occurs outside high-income countries, such as the Middle East or Africa. On the one hand, secondhand clothing, commonly known as *'mitumba'* in Tanzania, offers customers the possibility to consume quality brands at affordable prices, and the secondhand clothing value chain is a source of income by employing around 200 000 retailers in Dar es Salaam alone, according to estimates (Overseas Development Institute (ODI), 2017). On the other hand, the secondhand clothing trade can be potentially linked to a decline in local textile manufacturing. A more detailed discussion of the secondhand clothing trade is provided in section (4.1.1.).

Koszewska (2018) noted that falling costs, streamlined operations, rising demand and consumer spending contributed to significant growth in textile apparel production, which doubled between 2000 and 2014 when it surpassed 100 billion pieces for the first time. Furthermore, the textile apparel industry can be described as buyer-driven, illustrated by the trend of fast fashion.

The fast fashion business model is accompanied by rapidly changing apparel lines massively produced at the lowest cost and fast-changing fashion trends. This increases consumption, and the cheap production results in a reduced life span of clothing. In simple terms, it means the overconsumption combined with the notorious underuse of clothing resulting in high amounts of waste. While the traditional business model was

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU Bibliothek Your knowledge hub WIEN

two seasons for the year, the new fast fashion business model dictates up to 52 mini-season per year, presenting new things every few weeks to the buyer. This new model can be potentially linked to the increasing secondhand clothing trade in Africa. Brooks (2019) argues that the model manipulates demand for unnecessary products. While most Africans cannot consume fast fashion or buy the clothes they want, wearing used clothing in low-income countries is never a choice but a priority of the poor to meet basic needs (Brooks, 2019).

For the first time in at least one decade, the disruptive effect of the covid-19 pandemic caused negative economic profit for the fashion industry. Global apparel exports declined by almost 9% in 2020, driven by curfews, crumbled economy, and a scarcer consumer budget for discretionary spending (WTO, 2021). However, global apparel exports have rapidly recovered to roughly 95% of pre-covid 19 crisis levels by the end of 2020 (WTO, 2021). Moreover, performance in the first half of 2021 pointed to a return to positive economic profit by 2022 (McKinsey, 2021).

4.1.1 Tanzanian textile industry and secondhand clothing trade

Tanzania has a long tradition in the textile sector and is today a leading producer of organic cotton in Africa and one of the largest cotton producers in East Africa. It covers the entire value chain, including spinning, weaving, and manufacturing textiles and garments (Tanzanian Ministry of Industry, Trade and Investment, 2022). Tanzania's Textile Development Unit, a specialist, independently funded program within Tanzania's Ministry of Industry, Trade and Investment, is promoting the site because of its reliable and competitive cost of electricity, which is $ 0.11 per kWh, compared to $ 0.24 per kWh for Uganda, $ 0.185 per kWh for Kenya or $ 0.813 per kWh for South Africa (Tanzanian Ministry of Industry, Trade and Investment, 2022). The coastal region around the city of Dar es Salaam makes it further an attractive location for the development of textile and apparel manufacturing operations. However, based on Tanzania's position in the textile sector, it must be noted that the Textile Development Unit is looking for foreign investment to make the country a global textile hub rather than to promote a solidly established textile industry further.

Since 2005 Tanzania has enjoyed duty- and quota-free access to the U.S. market for approximately 6 500 products under the African Growth and Opportunity Act (AGOA). AGOA is part of the US' trade legislation and enhances the US' Generalised System of Preferences (GSP). It was extended in 2015 for a period of ten years (until 2025). Textiles and garments are covered by the AGOA provisions if made up (cut, manufactured, or

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

tailored) locally or made entirely from locally produced fibres, yarns, fabrics, or shaped knitted parts. Tanzania's exports to the USA were worth $ 131.5 million in 2017, while apparel products came in second at $ 40.5 million, making it the largest AGOA beneficiary sector in the country (AGOAinfo, 2022). Tanzania also exports to the European Union market under the EU-East African Community Economic Partnership Agreement created in 2014, providing tariff reductions (Directorate-General TRADE, 2022).

Over the last years, the textile sector has created an increase in manufacturing jobs and currently, the textile and clothing industry, together with the leather sector, is responsible for 14% of manufacturing employment, which makes it the third most crucial employment sector (Tanzania Competitiveness Report, 2015). Manufactured textile exports accounted for 14% of the total exports in 2015. Out of all related cotton products, raw and carded or combed cotton remains the most significant export product (Tanzania Competitiveness Report, 2015; East African Community (EAC) Industrial Competitiveness Report, 2017). These are mainly exported to Asian markets, with nine of the top ten destinations in Asia, the three most important being Thailand, Vietnam, and India (Tanzania Competitiveness Report, 2015).

As for the export of manufactured apparel products in Tanzania, the values are still relatively low, although it has increased in recent years. These exports mainly reach South Africa, the US, Switzerland, Zimbabwe, and Kenya. On the other hand, cotton fabrics are destined for regional markets such as Mozambique, Kenya, Zambia, France, and the United Kingdom in Europe (Tanzania Competitiveness Report, 2015). Due to global and regional demand dynamics, cotton apparel exports have been identified to be the most attractive product choice for the future of the entire East African region (EAC Industrial Competitiveness Report 2017). Cotton yarn has been further identified as a potential future export product due to its growing demand and higher price (Tanzania Competitiveness Report, 2015; EAC Industrial Competitiveness Report, 2017).

The underrepresentation of local textile manufacturers can be traced back to the 1980ies. The implementation of economic liberalisation policies on the African continent has led to a drastic decline in the local textile industries in sub-Saharan Africa. Scholars have widely studied this phenomenon, and it is well-documented (Gibbon, 1996; Onimode, 1988; Traub-Merz, 2006). Traub-Merz (2006) notes, among other things, that cuts in government subsidies through the structural adjustment programmes have led to the lifting of import restrictions and contributed to the devaluation of currencies. What seems evident from analyses is that African governments have not been able to face

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

global competition and promote local textile industries. One trend that goes hand in hand with the closure of textile factories is the simultaneous increase in imports of secondhand clothing to Africa (Brooks & Simon, 2012).

4.1.2. Secondhand clothing trade

Tanzania ranks among the top importers of secondhand clothing in sub-Saharan Africa (Observatory of Economic Complexity (OEC), 2022). One issue that is often discussed in the broader global context of secondhand clothing is the impact of these commodities on the local market in low-income countries to which they are shipped. Therefore, the first part of this section deals with the relation between the secondhand clothing trade and the decline of African textile industries in a historical context. The following step will highlight current practices in the secondhand clothing trade.

Secondhand clothing and local markets. Although several authors have discussed the relationships between used-clothing imports and the decline of African textile industries, and there seems to exist an intuitive connection, Brooks and Simon (2012) have questioned and investigated this link thoroughly. First and foremost, an evaluation of the entire African continent would be too simplistic and deceptive, as the various African states have their own characteristics in terms of history, geographical trade routes, culture, and socio-economic and political factors. Undisputedly, the secondhand clothing trade has grown from 1981 through 2000 due to waves of economic liberalisation in Africa; however, this must be regarded as *"an outcome of a broader pattern of economic liberalisation*" (Brooks & Simon, 2012). Hansen (2008), on the other hand, also notes in her research that the increase in the trade of secondhand clothing has taken place in parallel with the expansion of international humanitarian aid.

As far as Tanzania is concerned, the authors (Brooks & Simon, 2012) have pointed out that the port of Dar es Salaam is a virtual node in the geography of the secondhand clothing trade. Despite some success stories, such as that of the Tanzanian company MeTL, which was able to establish itself in the used clothing trade due to economic liberalisation and because it had enough capital, a functioning distribution network and diasporic connections abroad, and is still the largest company in the country today, African manufacturers generally faced increased pressure. The regional markets were flooded with used clothing and cheap new imports, especially from the Asian and Indian markets. This can be exemplified by *chitenge* (wraps of material worn as a sarong), an African printed fabric produced mainly in Tanzania and then exported to neighbouring countries, now competing with Chinese and Indian imports of cheap printed textiles and

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

secondhand clothes (Brooks & Simon, 2012). In this sense, local production can be undermined by cheap Asian imports to a certain extent. However, price is not the main criterion for regional trade in African markets. Secondhand clothes are not only bought for their attractive and affordable price but for their actual or perceived better quality. Buyers are willing to pay more for this supposedly better quality of secondhand clothes, especially shoes. A repeated observation in the markets in Dar es Salaam was that sellers often mixed new Chinese shoe imports with secondhand branded shoes from Europe or the US to disguise their origin. Other factors that influenced the buyer's choice were the perceived elegance of foreign products, the influence of the media and return migration or diaspora connections, and the uniqueness of the secondhand clothing, which allows one to create one's own identity.

In addition, the fast fashion business model and other trends of the twentieth century, such as manufactured obsolescence, as Brooks (2019) analysed, have transformed how women and men related to used clothing and accelerated the secondhand clothing trade.

Current practices in the secondhand clothing trade. The Global Production Network (GPN) offers a vivid approach to studying the secondhand clothing trade because it involves different actors at different stages, including non-firm actors and institutional frameworks, thus offering a multi-actor and multi-layered analysis (Brooks, 2013).

In the early stages of the GPN of secondhand clothing, mainly charitable actors can be identified to capture the value of donated and discarded unwanted garments. While the average consumer in industrialised countries tends to view secondhand clothes as waste or gifts when donated to a charity or business rather than as commodities, they still retain an exchange value through their physical properties (Brooks, 2013). Separated into various categories, weighed, labelled and tied into tightly packed standard bales of 45 to 55 kilograms containing the same type of used items, such as men's T-shirts, used clothing is sold as a commodity in a market-based transaction. The common practice in the secondhand clothing trade is shipping in containers that hold about 550 to 600 of these bales. Customers in African countries usually receive a mix of different bales. An illustration of this standard practice can be found in Figure 4. This also reflects the meaning of the Kiswahili word for secondhand clothing, as *mitumba* means bale or bundle. As Abimbola (2012) points out, the contents of sure bales remain hidden from retailers at the intermediate stages, as the cargoes are held unopened. This is critical as local traders at the end of the trade chain highly depend on the content and can increase their profit if getting many goods of good quality. Contrastingly, if they get ripped items or unfashionable and too large clothes, they could lower their budget (Brooks, 2013).

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

Furthermore, several authors have highlighted the unique role of diasporic and migrant communities, which play a crucial role in coordinating exporters and importers (Abimbola, 2012; Brooks, 2013). In addition, returning migrants can reinforce foreign fashion styles in their home countries.

Figure 4: A secondhand vendor at a local Dar es Salaam market shows his purchased bales; author's collection (2022).

As already pointed out, the secondhand clothing trade has experienced continuous growth in the past decades and continues to rise (EEA, 2019). The East African Community, made up of Burundi, Kenya, Rwanda, South Sudan, Tanzania and Uganda, was alarmed by the increasing imports in 2016. They agreed on a plan to phase out imports of used clothes to revive the collapsed textile industry in East Africa (AGOAinfo, 2022). This implies that a negative impact can be inferred. However, threatened by the possibility of losing eligibility to export duty-free to the U.S. market under AGOA, the East African countries finally cancelled the plan to phase out secondhand clothing imports in 2018 (AGOAinfo, 2022). To continue receiving benefits under the AGOA agreement, countries must conform to AGOA eligibility criteria, including removing barriers to US trade and investment (AGOAinfo, 2022). Instead, countries were free to adopt fiscal measures or other regional policies to promote local textile production. Tanzania adopted

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

the amendment to the EAC Common External Tariff, which means that the specific duty levied by Tanzania on imports of used clothing has risen from 0,2 USD per kilogram to 0,4 USD per kilogram. Based on a percentage of its value, the ad valorem duty rate levied on imported secondhand clothing remained unchanged at 35% (ODI, 2017). National standards for secondhand clothing foresee a ban on imports of secondhand underwear (or generally items categorised as 'next to skin' clothes, including pants, vests, brassieres, boxers and socks). However, it is difficult to eliminate these imports in practice (ODI, 2017).

Currently, academia and the public sector acknowledge a research gap in the study of mitumba. However, there are no further legislation or policy efforts to regulate this trade (Tanzanian engineering expert, personal communication, 3 January 2022).

4.2. Tanzanian legislation and policy on textile waste management

The Constitution of the United Republic of Tanzania (1977) provides in Article 14 the obligation to protect the human health of each citizen of Tanzania. Article 14 reads as follows: *"Every person has the right to live and to the protection of his life by the society in accordance with the law".* Indicated as *The Right to Life,* this stipulation is conclusively interpreted as the Right to a healthy environment. *The Environmental Management Act* (2004) was enacted to guarantee its implementation. Article 27 stipulates citizens' duties, specifically that *"every person has the duty to protect the natural resources of the United Republic"* (Constitution of the United Republic of Tanzania, 1977). Natural resources should be interpreted to cover the environment (NSWMS, 2018).

The Environmental Management Act (EMA) (2004) sets out a legal and institutional framework for sustainable management of the environment. Its overall goal is to promote this domain's protection, conservation, and enhancement. Its General Principles grant the Right to a clean, safe and healthy environment and entail the Duty to protect the environment. It establishes various administrative organs and institutions such as the *National Environment Management Council (NEMC)* and lays down general principles for management, impact and risk assessment, pollution prevention and control, environmental quality standards, public participation, and compliance and enforcement. Part IX of the EMA deals with waste management (NSWMS, 2018).

Waste Management Hierarchy. In line with the Right to a healthy environment on a constitutional level and compliance with the *Environmental Management Act (2004)* as well as *Environmental Management (Solid Waste Management) Regulations (2009),* Tanzania's overall policy on waste management is based on the 3R principle of

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU Bibliothek Your knowledge hub WIEN

sustainable waste management, namely (i) reduce, (ii) reuse, and (iii) recycle. This hierarchy was firstly proposed in *Tanzania's Waste Management Strategy 1998* for long-term waste management. It is used as guidance for a priority order in general waste prevention, legislation, and policy. The concept is illustrated below in Figure 5.

Waste Management Hierarchy

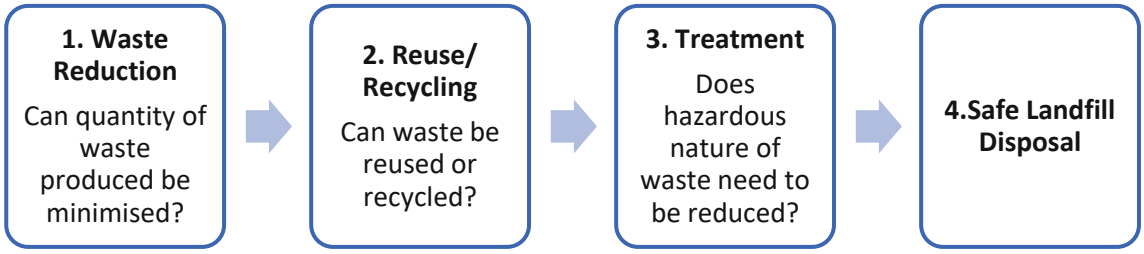

Figure 5: The waste management hierarchy, as depicted in Tanzania's Waste Management Strategy (1998), adapted: uppermost priority should be given to waste reduction, followed by reuse or recycling and its pre-treatment. Safe landfill disposal should be the last option of an ideal waste management system. Adapted by author.

Solid Waste Management. The Local Government (Urban Authority) Act (1982) provides, in section 55, the legal basis for urban authorities to *"remove rubbish and litter from any public or private place"* and to provide and maintain public litter bins for the temporary deposit and collection of waste. Dar es Salaam's City Council (DCC) regulations on waste collection and disposal also state that households must have separate waste containers for organic and inorganic materials. This enables the separation of wet and dry waste at the source. However, due to poor enforcement of the laws and lack of monitoring, these regulations are ineffective and minimal source separation is practised in Dar es Salaam (Hussein & Saphy, 2021). The following sections will highlight further reasons for the lack of cleavage.

NEMC, as mentioned earlier, is a statutory body established by *EMA (2004)* to advise and coordinate on environmental management issues, monitor and enforce environmental compliance and review Environmental Impact Assessments. It further supports the Dar es Salaam City Council in implementing municipal solid waste management regulations (NSWMS, 2018).

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

Other solid waste-related legislative acts are *The Public Health Act, The Public Procurement Act, The Public Procurement Act Regulations, and The Environmental Management (Solid waste management) Regulations* (Hussein & Saphy, 2021).

Waste Minimisation. The EMA, The Public Health Act, and The Environmental Management (solid waste management) Regulations require local authorities to ensure waste minimisation systems within their jurisdiction. The *Public Health Act* requires authorities to provide for the segregation of different types of waste or rubbish at the source to minimise solid waste and introduce standards for the type, size, shape, colour and other specifications of waste containers used. However, no waste minimisation initiatives were noticed or recorded to be driven by the municipality. The most common practice observed was collection and disposal (Hussein & Saphy, 2021).

Recycling. While recycling takes up a prominent part in European legislation and increasing emphasis is put on a circular economy approach by extracting as many high-quality resources as possible from waste (Circular Economy Package 2015, Circular Economy Action Plan 2019), there are no clear or detailed provisions regarding recycling or recycling of textiles in particular, in Tanzanian law.

In the following, a comparative study of EU and Tanzanian legislation and policy documents related to textile waste management was conducted to gather insights regarding the recycling potential of textiles.

The Waste Framework Directive (WFD) (2008) and its *amendments (2018)* as the legal basis for recycling and the circularity of resources in the member states of the EU outline in Article 4 the concept of the waste hierarchy in the following prioritisation order: (i) waste prevention, (ii) preparing for reuse, (iii) recycling, (iv) other recovery, and (v) final disposal as the last stage. A visualisation of the concept can be found in Figure 6. With the amendments to the *WFD*, textiles are now classified as mixed municipal solid waste under Article 3. In the context of waste prevention, Article 9 deals with the reuse and repair of textiles. Other obligations of the member states under Article 11 include introducing a separate collection of textiles by 1 January 2025 and reporting requirements regarding targets for preparing for reuse and recycling of textile waste by 31 December 2024.

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU Bibliothek Your knowledge hub WIEN

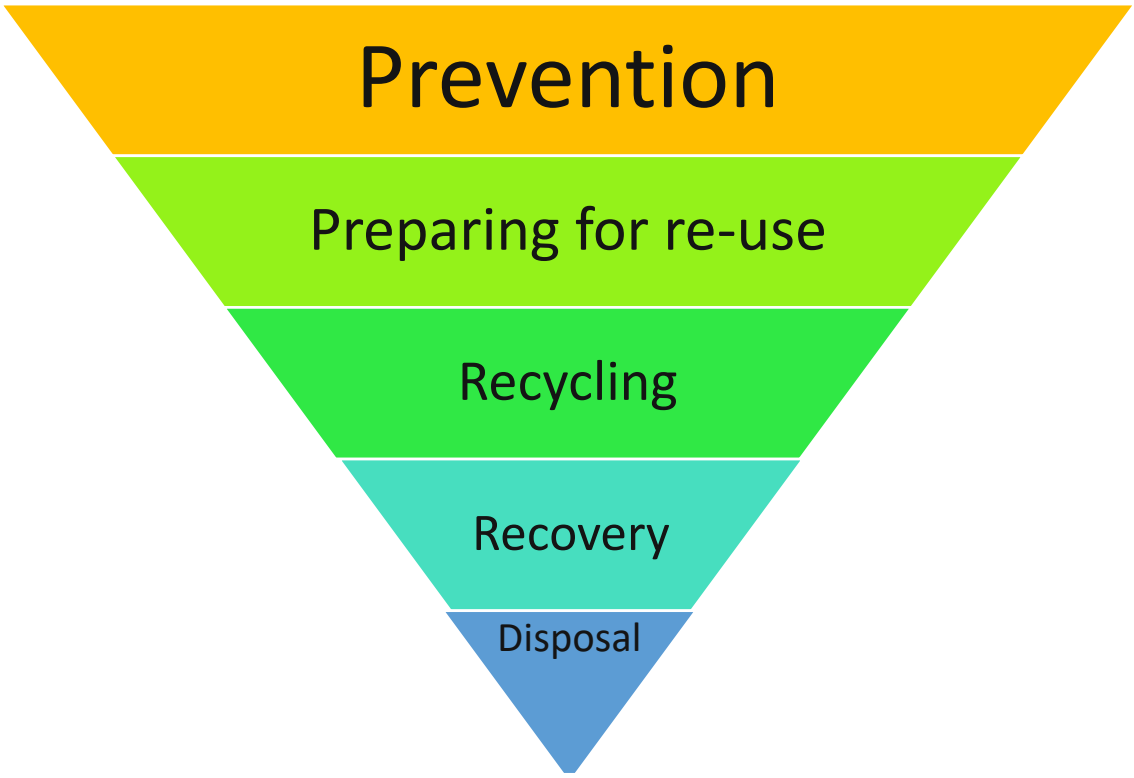

Figure 6: The concept of the waste hierarchy, as presented in Article 4 of the WFD (2008), provides for the following order of priority: The highest priority is given to waste prevention, followed by preparation for re-use, recycling or other recovery and final disposal as the last stage. This is the least preferred waste management option; it should only be used if no different 'best overall environmental outcome' can be reached otherwise. Based on European Commission (2022).

Besides the waste management hierarchy, which was firstly mentioned in *Tanzania's Waste Management Strategy (1998)* and overall encouragement of recycling at the policy level, the Tanzanian legislator does not provide any regulations concerning recycling. Specifically, no policy efforts have been made recently in the textile context. *The EMA (2004)* solely mentions recycling in the context of economic incentives and instruments for protecting the environment. According to Article 80 paragraph 2 (f), the return of bottles, plastics and metals for recycling and proper disposal is encouraged and also, product charges, such as charges on plastic or bottle packaging, are possible to discourage dumping or promote recycling (paragraph 3 (c)). *The NSWMS (2018)* recognises recycling as a critical approach. It acknowledges that more than 30-40% could be recycled, leading to a waste load reduction of about 50% (NSWMS, 2018). However, the lack of clear and well-defined regulations poses a significant challenge for implementing this goal and the waste management hierarchy.

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

Other solid waste management related legislation is the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal*, which Tanzania ratified in 1993. This is an international treaty aiming to reduce the movement of hazardous waste streams between high-income and low-income countries (Basel, 2022). Its regional counterpart is the *Bamako Convention on The Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa*; ratified by Tanzania in 1993 and ultimately coming into force in 1998 (United Nations, 2022).

Despite sound legislation in environment and waste management, scholars found that the level of compliance by public institutions, private companies and individuals was shallow (Hussein & Saphy, 2021).

4.3. Tanzanian waste management system

Solid waste management affects everyone, regardless of whether individuals dispose of their waste or governments provide waste management services to their citizens. Due to rapid urbanisation, population growth, and increasing economic performance, The World Bank (2018) projects an increase of 70% in solid waste from 2016 to 3,4 billion tons in 2050 globally.

Tanzania is home to over 60 million people (in 2021), with one of the highest population growth rates in the world (2.81 % in 2021) and associated urbanisation (United Nations Data, 2022; Statista, 2022). The gross domestic product was worth around 60 billion USD in 2021, and the annual GDP growth rate was 7% (United Nations Data, 2022). Dar es Salaam, Mwanza, Arusha and Mbeya are considered metropolitan cities where most population growth occurs (NSWMS, 2018). The interrelation of population growth and the environment is the subject of academic discussions and policy efforts; Tanzania's waste management system will, therefore, play an increasing role and face new stakes in the upcoming years.

Proper waste management is essential to building sustainable and liveable communities but challenges many low-income countries. This is primarily because effective waste management is expensive and often accounts for 20-50% of municipal budgets (World Bank, 2022). Whereas most of the municipal budget for solid waste management is used to collect and transport waste (International Solid Waste Association (ISWA), 2017). Compared to industrialised countries, residents of low-income countries, especially the urban poor, are more affected by unsustainable waste management practices, particularly when waste is dumped, buried or openly burned. These practices have

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU Bibliothek Your knowledge hub WIEN

serious health, safety and environmental consequences. In addition, poorly managed waste serves as a breeding ground for disease vectors, contributes to global climate change through methane formation, and fosters urban violence (World Bank, 2022).

Solid waste management is one of the most important responsibilities of all municipal authorities in Tanzania. This is a statutory duty by the Local Government Act 1982 paragraph 55 (g) and the EMA 2004. the local governments are responsible for solid waste management, collection and final disposal from households, market business areas, institutions, and industries (NSWMS, 2018).

Due to the limited waste management data situation in Tanzania, the city of Dar es Salaam is taken as a point of reference, as the data situation is more apparent here:

The Dar es Salaam city council (DCC) is divided into five municipal councils: Ilala, Temeke, Kigamboni, Ubungo and Kinondoni. These are also local districts at the same time and coordinate and supervise activities in their sub-wards. The DCC is responsible for the coordination, management of waste disposal and awareness-raising of waste management. In contrast, the municipal councils are primarily responsible for waste collection and night-time collection from households (NSWS, 2018). However, there is no formal structure or duty of direction from the DCC to the municipal councils, which operate primarily independently. In practice, waste management is handled individually by wards reporting to the municipal council. The system shows specific challenges in its operation, especially given the low institutional capacity and the high number of planned and unplanned wards, which amount to about one hundred. The Tanzanian recycling expert stressed that there is no formalised system for all neighbourhoods. Still, the waste management system is customised to specific areas depending on experience, preferences, and accessibility (Tanzanian recycling expert, personal communication, 19 May 2022). However, it must be noted that the range of services is mainly dependent on the income of the area: while private collectors generally provide most high-income residential areas, lower-income residential areas largely depend on community-based organisations (CBOs) for waste collection (Tanzanian non-governmental expert, personal communication, 22 January 2022).

The DCC has engaged in cooperation between public and private stakeholders and the formal and informal sectors to overcome financial constraints and institutional incapacities and find a viable solution for the partially inefficiently operating waste management system.

There are twelve formal waste collection service providers in the municipality, offering their services in 28 out of 36 wards. Of the twelve legal service providers, only eight are

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU Bibliothek Your knowledge hub WIEN

recognised by the municipality. The remaining four service providers are recognised by the heads of the wards and provide their services in consultation with them. However, the service providers who are recognised by the wards were selected through a competitive tendering process (Hussein, 2020).

Where there are contracted private sector actors, they are responsible for the collection of waste from their respective service areas as directed by the respective municipal council (NSWMS, 2018). The contractual nature of the collection services, which are usually concluded for one to three years, can pose challenges. The Tanzanian recycling expert explained that the short contract duration reduces companies' return on investment, so there is little incentive to modernise technology. This has implications for efficiency, service level, and the coverage of waste collected (Tanzanian recycling expert, personal communication, 19 May 2020). Some wards are served by informal service providers and get paid directly by citizens to get a more frequent service. However, this has some negative impacts as the waste is often dumped, and the municipal council does not get the RCC (Climate & Clean Air Coalition, 2015; Hussein, 2020).

The role of the informal sector is to collect solid waste and dispose of it at designated collection points. In addition, they are supposed to sort recyclable materials and sell them to recycling companies (NSWMS, 2018). A more detailed description of the informal sector is discussed in section (4.3.3.).

Residents are encouraged to separate waste and keep their surroundings clean. Moreover, they are responsible for paying their waste collection fees as part of their participation in the waste management programmes (NSWMS, 2018). The Refuse Collection Charge (RCC) is paid every month, ranging from a minimum to a maximum according to the average income of the areas. The fee is higher for industries and commercial businesses and can be negotiated according to their size and location (Climate & Clean Air Coalition, 2015). The costs of the RCC for households in the most affluent region of Dar es Salaam *Oysterbay* currently amount to 30 000,- TZS monthly, equivalent to around 12,- EUR, whereas the fee in low-income areas is 5 000,- TZS, equal to 2,- EUR (Tanzanian environmental entrepreneur, personal communication, 30 March 2022).

There are two schemes for the fee-based collection system in place. Eighter the fee is paid directly to the contractor who the DCC assigns to the respective street (whereby it is up to them to collect the money), or it is managed by municipal officers going from house to house and charging the fees (Tanzanian environment expert, personal

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

communication, 17 May 2022). This complex and inefficient collection method of RCCs, combined with a lack of alternative payment methods besides cash, results in a collection rate of less than 50 % in some of the wards (Hussein, 2020).

Due to the limited equipment capacity of the municipalities, the primary collection is regularly outsourced to private contractors and CBOs. Equipment, however, can be shared among those involved (Tanzanian Recycling expert, personal communication, 19 May 2022). In addition, equipment and tools are partly inadequate or in poor condition. A significant increase in equipment would be required to increase the collection rate. (NSWMS, 2018).

Eighter transported by private contractors directly or via transfer from the collection points, final disposal occurs at the Pugu Kinyamwezi dumpsite. In their study, Hussein and Saphy (2021) found no waste transfer station was observed or reported to have been designated by the municipalities. The common practice remains collection and direct disposal at Pugu Kinyamwezi (Hussein & Saphy, 2021). It is located 30 kilometres from the city centre of Dar es Salaam and operates for 24 hours. Management and operation lie within the responsibility of the DCC. Initially designed as a sanitary landfill, Pugu Kinyamwezi works as an open dumpsite without technical safety precautions such as soil lining, leachate and gas collection, soil cover, barriers and fencing. However, the financial resources were already exhausted in the construction phase (ISWA, 2017). Although there were some efforts from the Dutch Delegation to partially fund an upgrade to a sanitary landfill, the promotion has ultimately failed due to the lack of financial means from the DCC.

The Vice President's Office (2018) reported that the dumpsite is located around 100 metres from a residential area and is poorly managed. Due to occasional fire outbreaks, the dumpsite is sometimes topped with a cover (Tanzanian environment expert, personal communication, 17 May 2022). Besides lacking funds, the landfill faces other problems of natural origin. Dar es Salaam is a tropical city located on the coast of the Indian Ocean, which results in warm temperatures and high humidity (DCC, 2022). Due to the rain season in March and May and October and December, the collection services cannot reach the landfill partly because of no concrete access roads and the poor road conditions. Ultimately, this can stop proper waste disposal even for weeks. However, in recent years efforts have been made to improve the infrastructure (Tanzanian environment expert, personal communication, 17 May 2022). Besides, the city holds various informal dumpsites located in different areas and along river valleys (Vice President's Office, 2018).

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

Due to financial constraints and capacity limitations, all the more, the operation of municipal services requires integrated systems that include communities, NGOs, and private stakeholders to be efficient and sustainable.

4.3.1. Current practice in waste management

Currently, the city of Dar es Salaam has a population of around 4,5 million people, although the number tends to be higher during the day when taking into account people from outside the city who come to work in the informal sector. According to a study by the United Nations, it is projected to reach megacity status with over 10 million residents at the beginning of the 2030s (UN DESA, 2018). This challenges critical infrastructure, whereby the urban poor is the most vulnerable group prone to the adverse effects of inefficient waste management. As around 70 % of the population live in unplanned and under-serviced areas of the city, this constitutes a significant challenge.

According to the NSWS (2018), it is estimated that the current daily solid waste generation rate per capita is about one kilogram per capita. In contrast, typical values in the sub-Saharan African region lie around 0.46 kilograms per capita per day (World Bank, 2018).

Depending on the infrastructure of an area, the collection is handled with the contractor's vehicles or pushcarts in the form of a door to door collection. While contractors can reach the Pugu Kinyamwezi dumpsite, CBOs can barely travel longer than a few kilometres (ISWA, 2017).

The NSWMS (2018) estimates that less than 40 % of the total waste generated is appropriately collected and disposed of at the Pugu Kinyamwezi dumpsite or otherwise recovered. The Tanzanian environment expert stressed that collection services had improved regardless of the challenges and estimated the current collection rate to be about 50 % (Tanzanian environment expert, personal communication, 17 May 2022). The collection is carried out daily, and ideally, it should be guaranteed that all areas are served once weekly (NSWMS, 2018).

However, the remaining fraction is not appropriately disposed of, including practices such as burning, burying and dumping. The waste clogs drainage systems, pollutes river beds and the environment and poses a health risk in residential areas for impoverished communities. The uncontrolled burning of everyday materials releases highly toxic dioxins and furans (so-called POPs – persistent organic pollutants). In addition, soot particles can cause cancer and contribute to global warming (Unitar, 2022). While

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

burying waste is commonly practised in rural areas because there is much surface area, burning is practised in cities, including hazardous waste, such as medical waste from health care facilities (Vice President's Office, 2018). The burning of plastic bags is frequently used to light up charcoal (Unitar, 2022). Waste is also used as a form of erosion control and dumped into river beds nearby -often informal- settlements (Tanzanian non-governmental expert, personal communication, 22 January 2022).

Regarding the waste composition, the following was reported for 2014: organic materials, including food and garden waste (31,5%), plastics (22%), paper and paperboard (12%), glass (9%), other inorganic materials (7%), textiles (5%), and metals (0.5%), (NSWMS, 2018). Another report by the Vice President's Office reported the following waste composition in 2018: organic materials (49%), plastics (10%), paper and paperboard (8%), ceramic and stone (6%), metals (5%), glass (2%), leather and rubber (6%), textiles (5%) and other inorganic materials (3%). Both sources for the waste composition represent Tanzanian national documents. It remains unclear how the waste composition analysis has been carried out. However, a more detailed analysis of the waste composition could offer insights into its potential uses and applications and improve the currently operating waste management system.

Generally, sorting is not done at its generation points. This is due to various reasons, such as the lack of financial means to buy waste bags for the separation of materials and the relatively poor environmental education. The only exception in sorting waste is biodegradables collected from the market areas. However, very little processing (composting) of biodegradable waste is performed (NSWMS, 2018).

The city holds several - often informal - collection points, which usually accept every mixture of solid waste regardless of its composition. There, secondary collection by the private sector or municipalities takes place. There are around one hundred collection points within the city area (Tanzanian recycling expert, personal communication, 19 May 2022).

Recyclable materials in the public waste streams generally include plastics such as plastic bottle caps and plastic beverage bottles, paper and cardboard, and glass beverage bottles and glass jars. The recycling industry in Tanzania cannot effectively recycle the most significant part. Generally, the operating recycling companies are business-oriented, and there is a high rate of fluctuation (Tanzanian non-governmental expert, personal communication, 22 January 2022). Due to the lack of recycling facilities in the country, domestic and international trade in recyclables exist; however, they were not part of this study.

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

Out of the 30-40% of high-value recyclables from the waste stream, less than 10% are recovered at the source or collection points. In contrast, waste pickers collect limited quantities of high-value recyclables at the Pugu Kinyamwezi landfill due to the difficult working conditions. The recovered materials include, as mentioned earlier, rigid plastics, scrap metals, aluminium cans and high-value paper.

4.3.2. Textile waste management in Tanzania

Pre-consumer. Despite the increasing number of textile apparel manufacturing sites in the country, the recognition of pre-consumer textile waste is still relatively low. Specific data or studies on pre-consumer waste in Tanzania are not available. However, it can be stated that Tanzania is an attractive location for investors due to its abundance of resources and exceedingly low labour costs in the textile and garment industries, so an increase in production capacities in the textile industry is visible (Tanzania Industrial Competitiveness Report, 2015; Naidoo & Ndikumana, 2020).

There are no legislation or policy documents regarding textile waste. This was confirmed by the Tanzanian environment expert, who stressed that all industries, including textile and apparel, are under the supervision of the NEMC to comply with technical and environmental requirements under national law. There are clear regulations for pollution, especially air pollution and wastewater discharge. However, the challenge here is that the legal provisions are primarily based on western benchmarks, and the local authorities do not have the necessary technologies to prove such precise levels of measurement. The Tanzanian engineering expert also emphasised the lack of appropriate technologies (Tanzanian engineering expert, personal communication, 3 January 2022). The common practice is that manufacturing sites are allowed to remain in operation if they meet at least 50% of the required standards and show commitment to apply some form of pollution control and move towards compliance with the standards. (Tanzanian environment expert, personal communication, 17 May 2022). In this respect, the standards are lowered in practice. Other aspects also flow into the assessment - the expert mentioned, for example, that NEMC considers the investments made to establish the site. In addition, an opportunity is given to improve the environmental performance so that manufacturing sites can remain open.

The interview with the Tanzanian environmental entrepreneur revealed that several tailoring workshops producing male and female apparel, curtains, bags or cloth bracelets exist in Dar es Salaam. He studied the assessment of needs and options in techno-social management of material textile waste in a case study in the Ilala ward from April to July

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU Bibliothek WIEN Your knowledge hub

2020, interviewing 40 tailoring workshops in 5 sub-wards of the Ilala municipality. His study showed that around 1 460 kilograms of textile waste were produced per day from all tailoring workshops. According to his calculations, about 50% of the textile material waste ended up in the public waste stream, 3-10% was sold to recyclers, and around 2% was burned. (Tanzanian environmental entrepreneur, personal communication, 30 March 2022). This study highlights a considerable amount of textile material waste from small tailoring workshops that are not appropriately handled. When considering the investigation by Aus et al. (2021), it must be borne in mind that small manufacturers generally produce more textile waste than bigger ones. Hence, when considering material textile waste from other municipalities, which this study has not assessed, the amount of textile waste created is substantial. Figure 7 illustrates the textile material waste from a tailoring workshop in the municipality of Ilala in Dar es Salaam and Figure 8 shows the outside area of a tailoring workshop in the municipality of Ilala in Dar es Salaam.

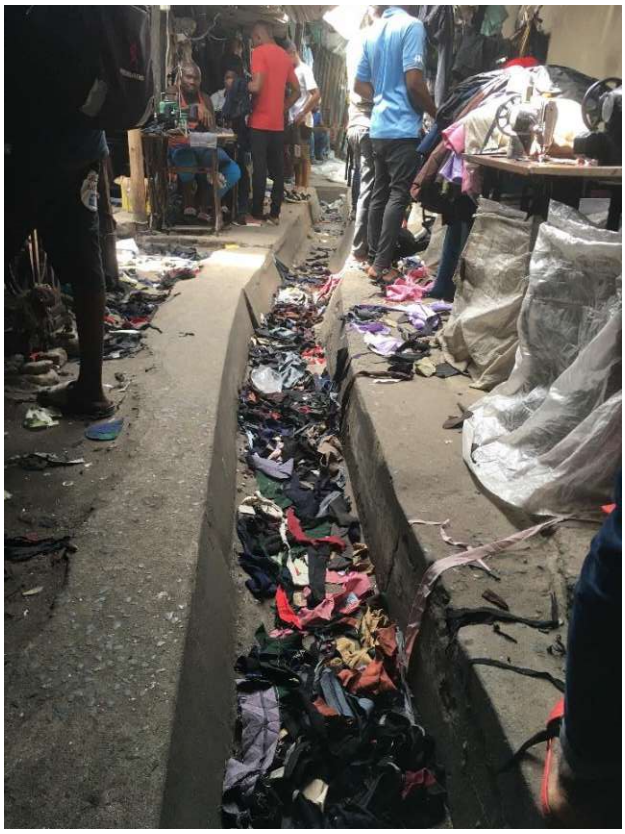

Figure 7: Textile material waste from a tailoring workshop in the municipality of Ilala in Dar es Salaam; the photo was taken by Cecil Sagawala (2020).

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

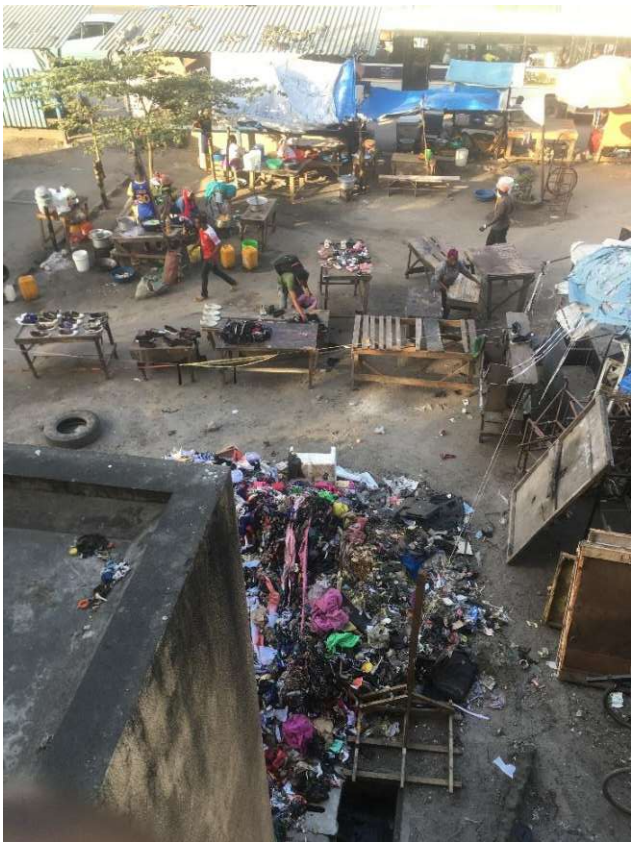

Figure 8: Outside area of a tailoring workshop in the municipality of Ilala in Dar es Salaam; the photo was taken by Cecil Sagawala (2020).

However, there is a significant lack of data on pre-consumer textile waste. As identified in the NSWMS (2018), total industrial waste, including manufacturing and production processes from all industries combined and the commercial and business waste, accounts for approximately 20% of the complete waste generated in Dar es Salaam. Moreover, it is unclear if all textile waste from industrial activities is collected. Some manufacturing sites were reported to leave textile waste at their respective location and let the materials rotten (Tanzanian recycling expert, personal communication, 19 May 2022).

Post-consumer. Comprising households at a rate of 75 %, markets at 3,5 % and streets at 0,5 %, these sources from post-consumer activities take up the most significant part of Dar es Salaam's waste generation (NSWMS, 2018).

The generation of textile waste at the household level is potentially influenced by increasing new and unused textiles in people's homes. The clothes are unused for various reasons, such as biasness, the change in body size, destruction by rats or accidents and unpleasant odour. More and more, changing fashion trends are also playing a role in the disposal of clothing (Tanzanian environmental entrepreneur, personal communication, 30 March 2022). Due to the lack of sorting of waste at its

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU Bibliothek Your knowledge hub WIEN

generation point, a collection point or a separate collection scheme, textile waste is mixed with other solid waste and then, ideally, collected by the collection services. According to a study carried out by Nipe Fagio in 2021, textiles were the fourth most disposed of items in the waste stream from households. Clothing items, mattresses, and shoes combined made up 15,6 % of the total residual waste collected (16 546 items) for auditing (Nipe Fagio, 2021). When comparing the data available from the NSWMS (2018) and the Vice President's Office (2018), an increase in textile waste in the post-consumer waste stream is notable, which increased from 1% to 5% in the period from 2012 to 2014 but remained constant at 5% until 2018. Also highlighted was the conspicuous amount of shoes found during beach cleanings carried out annually by Nipe Fagio (Tanzanian non-governmental expert, personal communication, 22 January 2022).

As reported by the Tanzanian environmental entrepreneur, about 60% of households dispose of their textile waste with residual solid waste. Only about 3% are donated to more vulnerable groups, and approximately 3% are downcycled into lower-value applications such as surface cleaners. When it comes to clothing from passed away people, about 50% is usually given to family members or friends. The rest is disposed of via the mixed residual solid waste. Overall, most of the people he interviewed acknowledged the problem of textile waste in their respective wards. However, only a fraction of them was aware of the possibility of the reuse of textile waste (Tanzanian environmental entrepreneur, personal communication, 30 March 2022). This poses a challenge in terms of value creation from unused textiles.

Standard practices of textile waste management also include burying, burning or dumping by the road or into the drainage canal. Followingly, dumping leads to pollution of river beds and high piles of waste near bridges. Figure 9 below illustrates dumped textiles in various forms, including clothing, interior items and footwear.

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

Figure 9: Dumped textiles in various forms, including clothing, interior items and footwear in Dar es Salaam; the photo was taken by Cecil Sagawala (2020).

A case study conducted in three markets in Dar es Salaam is used to illustrate the waste management of textile waste from secondhand clothing. A total of sixteen secondhand vendors and four tailors were interviewed at three secondhand markets in the district of Ilala and Kinondoni; Ilala market, Kariakoo market and Manzese Tandale market, in the form of semi-structured interviews. Secondhand markets in Tanzania are widespread and popular. A large part of the population shops at secondhand markets because of the favourable prices. Figures 10 and 11 illustrate the spatial conditions of the study area. At the Manzese Tandale secondhand clothing market, pictured in Figure 10, megaphones were used by the vendors to advertise their wares.

The small-scale survey evaluated textile waste management from imported secondhand clothing as part of the post-consumer waste stream. The aim was to determine factors influencing a textile waste generation and collection and highlight trends at the market level. Moreover, practices and potential options in textile waste management were assessed. Conclusively, the case study aimed to identify standard practices in textile waste disposal and determine awareness about textile waste management and its importance for the environment.

The following scheme was applied to the small-scale survey:

(1) The introductory question concerned general information about the person and the business's operational structure.

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

(2) The second part concerned the number of bales purchased per week and the quality of their content.

(3) A particular highlight was put on textile waste's perceptiveness, disposal practices, and potential options for its management. In addition, participants were asked to indicate the amount of textile waste generated per day.

The following is a summary analysis of the results of the discussions held.

Each of the vendors specialised in a particular type of clothing, such as men's trousers, baby clothes or women's dresses. Four saleswomen said they specialised in baby and children's clothes because they were popular, there were many children, and people wanted to buy them. The vendors indicated that they obtained a specific kind of clothing or a mix of clothes when purchasing a bale. All sellers agreed that the quality of the items purchased had a significant impact on their profit margin. These statements are consistent with Abimbola (2012) and Brooks (2013, 2019), who have stressed that secondhand vendors were highly dependent on the content of the bales.

On average, a piece of clothing cost around 1000,- TZS, equivalent to 0,40 cents, with well-known western brands traded at a higher price. Some stalls sold new items of Asian origin mixed with secondhand clothes from other parts of the world.

Twelve vendors indicated that if items could not be sold, they would be resold to the automotive industry or construction industry. One discussant named the newspaper industry as a potential customer. Unused and unsold items would downcycle to lower-grade applications for cleaning purposes. However, this only applied to cotton-based items as synthetic textiles are unsuitable. Textiles in a deficient condition that did not find a new use in a cross-sector must be disposed of. Four of the vendors stated that everything would be sold. One discussant mentioned that he gave items out for free if he could not sell them for more than ten months.

No collection bins or areas for disposal were located in any of the markets.

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

Figure 10: Manzese Tandale secondhand market in Dar es Salaam; author's collection (2022).

Figure 11: A stall specialising in men's trousers at Ilala market in Dar es Salaam; author's collection (2022).

Secondhand items have different sizes, fashion styles and degrees of wear. For this reason, many clothing items must be retailored to fit the customer's body shape. Therefore, the secondhand clothing markets are closely linked to the retailoring sector. Typically, there was a retailer next to almost every stall. The tailors frequently resew too big textiles, usually from the US. One tailor indicated that she would modify the clothes, combining two or more items to upcycle them and sell them herself.

Regarding the scrap material from the modification process, all tailors stated that it would be resold to other industries per kilogram. These industries used the scrap material to make pillows or carpets. However, very tiny scrap parts could not be used for other

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

applications and must be disposed of. The indicated standard method for disposal was burning. The scrap material was burned around the area of the markets. In addition, some of the materials were used as a lighting source for cooking. Figure 12 shows a female tailor at Ilala market in Dar es Salaam while resewing secondhand Adidas training pants for a new customer.

Figure 12: A female tailor at Ilala market in Dar es Salaam while resewing secondhand Adidas training pants for a new customer, author's collection (2022).

Although all interview partners were aware of the overall waste management's importance for the environment, some of them resorted to unsound practices of textile waste management due to the lack of other disposal options. The burning of scrap materials seemed to represent a logical consequence. The purchase of secondhand clothing remnants by other industries is a standard method of downcycling. However, how much of the remaining secondhand clothing is used for these purposes is unclear.

In this regard, the Tanzanian recycling expert stressed that there is no systematic or commercial solution for textile waste in Tanzania. The practised downcycling options in the carpentry, automobile, or furnishing industry, as mentioned earlier, represent only limited application cases (Tanzanian recycling expert, personal communication, 19 May 2022).

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

4.3.3. Informal sector

The informal sector plays a crucial role in Dar es Salaam's waste management system, especially in the recovery of materials. Thereby, it contributes to ensuring a sound environment and mitigating climate change. However, their critical environmental, economic and social role is not consistently recognised by the government, municipalities and society. The experienced inequalities can range from social stigmatisation and municipal or security guards' mistreatment at dumpsites (GAIA, 2021).

Waste pickers eighter operate at the collection points and cooperate with the CBOs, independently with recycling companies, or directly at the Pugu Kinyamwezi dumpsite (Climate & Clean Air Coalition, 2015; Tanzanian recycling expert, personal communication, 17 May 2022). The Tanzanian recycling expert explained that whenever he requires a specific material, the word is spread, and waste pickers get the material and are paid directly by him (Tanzanian recycling expert, personal communication, 17 May 2022). It is reported that around 600 to 700 waste pickers work and live at the Pugu Kinyamwezi dumpsite under health-hazardous conditions and retrieve approximately 9 to 10 % of the waste at the dumpsite (Vice President's Office, 2018). It is unknown how many waste pickers operate in Dar es Salaam; the number could be between 2 000 and 10 000 (Tanzanian recycling expert, personal communication, 17 May 2022).

There is a significant gap in data and research regarding the informal sector. Efforts are currently underway to identify waste pickers within the scene and support and strengthen their position. The aim is to register all those working as waste pickers and get reliable data. If waste pickers do not have an address, the registry attempts to link them to a nearby religious or health facility to ensure some reference point. Waste pickers are also free to nominate a reference person. In this sense, an attempt is also made to carry out a background study through the data situation to find out from which life situation or motivation these people work in the informal sector. Ultimately, this registering system could be linked to getting access to medical insurance, which would benefit this marginalised group. Most people working in this domain do not have access to smartphones and cannot enter a digital system to register themselves. Therefore, it is vital to reach out to them and give them a voice. Covering work specific information, the register should indicate the area of work, the type of waste picked, and if they were working for a company, a group or themselves (Tanzanian recycling expert, personal communication, 19 May 2022). Efforts to organise themselves have been minimal (GAIA, 2021). Therefore, it is essential to focus on the valorisation of waste pickers' work, create

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

awareness among community members and provide them with adequate protective clothing (Tanzanian non-governmental expert, personal communication, 22 January 2022). This could help mitigate the lack of recognition from the government and marginalisation from community members.

4.4. Challenges in textile waste management

The general conclusions from the waste management system described above include high operational costs, which cannot be covered entirely by RCC and consume the most significant part of the DCC's budget. Moreover, there is a significantly limited capacity in equipment which influences the level of service and the frequency of collection. In addition, the relatively long distance to reach the Pugu Kinyamwezi dumpsite, combined with the poor condition of equipment and poor road conditions, hamper the operationality of the waste management system. More transfer stations would be needed to overcome the challenge of distance (Tanzanian non-governmental expert, personal communication, 22 January 2022). There is a lack of supervision due to the intransparent system of responsibilities between municipalities and the wards. In addition, low law enforcement capacity exists. This may also contribute to the system's inefficiency and results in low collection rates and poor coordination of collection routes. An increase in trained staff could probably help overthrow some of the mentioned challenges; however, it fails because of the financial means.

Generally, poor environmental education and lacking awareness about solid waste management in society were stressed by all Tanzanian experts (Tanzanian engineering expert, personal communication 3 January 2022; Tanzanian non-governmental expert, personal communication, 22 January 2022; Tanzanian environmental entrepreneur expert, personal communication, 30 March 2022; Tanzanian environment expert, personal communication, 17 May 2022; Tanzanian recycling expert, 19 May 2022). As the benefits of proper solid waste management are not felt right away, the public sector prioritises and invests in more evident and socio-politically present issues such as the medical or transport sector. However, the Ministry of Health embarked on a national sanitation campaign which started six years ago. The first phase ended last year and included, among other actions, national-wide TV contributions about proper solid waste management. Due to burying and burning practices and littering, the campaign focused on environmental education in this regard and the promotion of adequate collection bins (Tanzanian environment expert, personal communication, 17 May 2022). However, such efforts are difficult to implement if citizens lack the financial means to afford an adequate

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

collection bin. In addition, only 44,6 % of Dar es Salaam's population has access to waste collection services. In the absence of primary waste collection, the remaining community resorts to dumping waste, including littering, burying or burning (Nipe Fagio, 2021). In this regard, it is vital to promote environmental education. If people understand that clogging drainage systems and dirty rivers are a source of mosquito breeding sites and attract rats or mice, they will think about dumping their waste (Tanzanian non-governmental expert, personal communication, 22 January 2022).

The inaccessibility of some areas attributed to poor urban planning poses another obstacle to appropriate waste collection (Tanzanian environment expert, personal communication, 17 May 2022).

The general challenges in waste management outlined above show the limited possibilities concerning textile waste. According to the Tanzanian environmental entrepreneur, the practices in textile waste management mentioned earlier constitute a significant challenge in its direction, as it shows the lack of options to manage textile waste in the first place. In addition, textile items and waste lose their potential value as a commodity (Tanzanian environmental entrepreneur, personal communication, 30 March 2022). Moreover, textile waste is not the focus of legislation or national policies. This indicates that there is also a lack of awareness in this respect in the public sector. However, general stakeholder-driven circular economy approaches could enhance the current situation in textile waste management.

In the context of a technical approach, adopting economically feasible textile recycling technologies offers new opportunities. There is a lot of potential in the market; however, not yet on a large scale. This was confirmed by the Austrian fibre expert, who stated that materials should ideally be recycled into materials of equal or higher value. Products would have to be made of one or two materials for this to be possible. In addition, technologies and quantities would have to be in place that allows for economical recycling (Austrian fibre expert, personal communication, 20 May 2022). Whether the current legal situation and economic environment create sufficient incentives to invest in textile recycling, especially in low-income countries, is further unclear. One company in Kenya currently focuses on the bottle-to-fibre process; the predominant mechanical method applied in textile recycling (The Megh Group, 2022). It is the only company engaging in textile recycling operating in the whole African region. While this contributes to tackling the plastic waste problem in Kenya that the entire African continent faces, its extent is difficult to estimate. Above all, the existence of one company for the whole

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

continent highlights the limited access of African countries to sophisticated recycling technologies due to financial constraints in the first place.

To ensure environmentally-friendly management of textile waste in the face of ever-increasing quantities, it is essential to overcome disagreements on the textile recycling issue and develop forward-looking, inclusive and fair concepts. Legislation and policy have a crucial role to play in this regard. A continental approach already exists. Tanzania is a member of the African Ministerial Conference on the Environment (AMCEN), established in 1985 with the mandate to advocate for environmental protection in Africa (UNEP, 2022). In 2019, the ministers agreed on the Durban Declaration on Environmental Sustainability, the first pan-African political declaration on environmental sustainability and circular economy. In parallel, the African Circular Economy Alliance (ACEA) was established. It includes textile-related measures, particularly standards that enable upcycling secondhand clothing (CUTS, 2022). This sets the potential for other textile-related frameworks on the national level.

4.5. Mapping the potential for managing textile waste

The following possibilities for managing textile waste are discussed under the 3R principle of reducing, reusing and recycling along the waste hierarchy.

Prevention. Due to the limitations in recycling and upcycling opportunities, stakeholders must consider alternative solutions to reduce textile contributions in pre-consumer and post-consumer waste streams. In parallel, as called for in the regulation of plastics by Nipe Fagio, the instrument of the EPR could provide a remedy (Nipe Fagio, 2021). This concept requires producers and manufacturers to take ultimate responsibility for their products, ideally reducing pressure on the environment. General considerations regarding the instrument of the EPR can be found in section (3.5.). The EPR scheme represents a prevention-related solution as it focuses on rethinking how items are manufactured, recycled, and disposed of. Generally, the collection of textiles in organised methods by charitable organisations or businesses is rare on the African continent. *Africa Collect Textiles (ACT),* an NGO-based initiative, introduced a system of collection bins in Nairobi in Kenya in 2013 and in Lagos in Nigeria in 2021. ACT collects, sorts, and processes all types of textiles. Some are then being donated, resold, recycled into new yarn or upcycled into locally desired products, including shoes, carpets, and bags (Kasper & Stroomer, 2021). As the informal sector plays a crucial role in recovering materials, its involvement in the EPR scheme poses a possible solution to the lack of separate collection schemes in Tanzania. However, the lack of data on the

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU Bibliothek Your knowledge hub WIEN

undocumented practices of waste pickers and potentially harmful aspects relating to unsustainable practices such as dumping, as laid down in section (4.3.), or other illegal activities, can represent a challenge in this regard.

Reduce. A recent study regarding textile waste generated during production in Bangladesh revealed potential applications for it. The authors argued that it could provide scope for new business opportunities, products, and services and create new employment. However, collaborations and strategic approaches from stakeholders through effective policymaking, governance, and implementation would be essential to accelerate these processes (Akter et al., 2022). This was confirmed by the Tanzanian recycling expert, who is advocating and coordinating on behalf of commercial and industrial waste management and recycling in Tanzania to create decent jobs and promote environmental resilience. The 'Taka-ni-ajira' initiative (Kiswahili term for waste - decent job initiative) aims to identify, coordinate, and support relevant stakeholders in waste management and recycling. In this sense, the government's support is crucial and inclusive; forward-looking legislation could contribute to pursuing the initiative's goal. Shortcomings of the current waste management regulations and policies, such as the relatively short duration of contracts with private stakeholders, should be addressed and alternative solutions developed. However, to guarantee evidence-based dialogues, synergies between academia, society, and public stakeholders should be supported and further improved (Tanzanian recycling expert, personal communication, 19 May 2022).

Product-related solutions for textile waste could include the sewing of big blankets that could be used for refugee camps serving as a sleeping cover or sun protection. Furthermore, textile waste in children's toys could be a potential application (Tanzanian recycling expert, personal communication, 19 May 2022). Both solutions refer to upcycling. Upcycling initiatives have been already developed in Tanzania. The Tanzanian environmental entrepreneur started an initiative to retail jeans to make bags out of them two years ago. At first, people were reluctant to donate their old clothes and perceived it strange. However, the enterprise has proven successful, the purchasers of his products being mainly foreigners and NGOs (Tanzanian environmental entrepreneur, personal communication, 30 March 2022).

Reuse. While it is common to give clothes to family members, few people donate clothes to more vulnerable groups. This could be partly attributed to spiritual bias. The Tanzanian environmental entrepreneur explained that some people believe that when passing on clothes also, karma is passed on. This could lead to bad intent and evil deeds passed on with the old clothes (Tanzanian environmental entrepreneur, personal

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

communication, 30 March 2022). On the other hand, lacking awareness about reuse options and the lack of separate collection schemes hinder this practice. The Austrian fibre expert assessed the concept of reuse as the most practical solution for textile waste in low-income countries. He justified this assumption with the lack of technological backup in the country to realise a sophisticated recycling system. Hence, a good collection and sorting method should be in place, which could be realised with the capacity in low labour costs (Austrian fibre expert, personal communication, 20 May 2022).

Recycling. The section about challenges in textile waste management (4.4.) has highlighted the limited applicability of textile recycling options in Tanzania. What follows from the waste management and related challenges described above is that the definition of recycling in a narrow sense and the concept of recycling per se needs to be adapted to the circumstances in low-income countries. This has been confirmed by the Austrian fibre expert, who suggested modifying the term recycling and enclosing upcycling. By using lower labour costs, the materials could be converted into other products (Austrian fibre expert, personal communication, 20 May 2022). Therefore, in the traditional sense, textile recycling can only be an option in Tanzania if foreign investment is made in this area.

Disposal. As far as the disposal stage is concerned, a possible solution for textile waste could be using termites, potentially feeding on textile waste. Termites are common in tropical regions, and their recycling of wood and plant matter is considered essential for the ecological system (Tanzanian recycling expert, personal communication, 19 May 2022). This raises an interesting scientific discussion, but it comes with some limitations. Above all, it is questionable whether termites could also decompose synthetic substances. Given the amount of polyester-based clothing, this point seems more worthy of consideration. In addition, termites would always produce certain by-products, so the outcome is not entirely controllable. (Austrian fibre expert, personal communication, 20 May 2022).

The following paragraphs discuss other potential actions for managing textile waste.

Circular Economy. Legislative ways forward toward a circular economy model could create the necessary legal conditions for innovative circular economy business models and assist in accessing new technologies, including technology transfer and knowledge. Besides, monetary and fiscal incentives could promote investment and support entrepreneurs in developing environmental-friendly projects. Policy efforts should include circular economy concepts for sustainable development and various actors to

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

enhance sustainable production and consumption patterns. In this way, commitment to SDG 12 could be ensured. Other African countries are already on their way. For comparison, Rwanda introduced the *Rwandese National Environment and Climate Change policy* in June 2019, in which one of the guiding principles is "Endeavour to promote circular economy and industrial symbiosis (CUTS, 2022).

International trade can play a crucial role in decoupling economic growth from the consumption of finite resources (Industrial Analytics Platform UNIDO, 2022). In this way, the circular economy model is linked with the global production system. The waste output is reduced by reinserting waste and scraps into refurbishment and remanufacturing production processes. Enhanced industry supervision, improved data on pre-consumer textile waste and promoting development in the remanufacturing sector could contribute to this. However, it must be noted that this solution requires a cross-supply chain approach and relies on global cooperation and mutually benefitting trade regulations.

Waste Exchange Platforms. The One Planet Network (2022), responsible for the implementation of programs on sustainable consumption and production and works towards achieving SDG 12, defines waste exchange platforms as a "*centre platform for information exchange on supply and demand of all types of secondary materials that are the result of waste management or that can be generated during the production process."* Such digital platforms serving as marketplaces can offer a way to a circular economy approach. In a business-to-business marketplace, discarded products, components or recyclable fractions can be exchanged between different companies (sectoral or cross-sectoral) in a value network. Thereby, reuse, remanufacturing, recycling or proper waste treatment can be facilitated. However, there are some caveats regarding implementing waste exchange platforms in Tanzania. The implementation is hampered by the strict allocation of a district to waste collection services and recycling companies. In addition, waste pickers who are heavily involved in the recovery process often do not have access to digital services. For these reasons, such efforts have already failed in the past (Tanzanian recycling expert, personal communication, 19 May 2022). One solution could be a waste exchange platform coordinated by the public sector. Although such an introduction could be a decisive push factor in this area, several constraints on the part of the public sector should be considered. These could include the lack of technological know-how if unfamiliar with the digital industry, corruption and low efficiency. However, with no legislative and policy efforts in this regard, the realisation seems far away.

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

Overall, it must be acknowledged that there is a significant lack of human, financial, technological and technical capacities in low-income countries that hinders the implementation of national plans and policies related to a circular economy (CUTS, 2022).

Recycling targets. When it comes to recycling targets as a monitoring tool in waste management (for example, as provided for in European legislation in the WFD for preparing for the reuse and recycling of textile waste), it must be noted that these instruments are not always the best option to reach a specific goal. However, the purpose of waste management is not recycling targets but the protection of people and the environment and the conservation of resources. Recycling targets can contribute to this or help measure these targets in a certain way. This should always be analysed in whether a particular mark can be achieved at a reasonable cost, as the last 5-10% cost may be higher than the potentially achievable benefit. First of all, in the case of Tanzania, a separate and organised collection scheme would have to exist to implement this measure. However, this measure does not serve the purpose when considering the challenges and financial constraints in Tanzania's waste management system.

4.6. Limitations to the research topic

A limiting factor of the literature review was that it was conducted exclusively in English and, alternatively, in German. However, this factor was mitigated because English, along with Kiswahili, is an official language in Tanzania and is used in higher education.

The primary data collection technique of the small-scale survey had some limitations. Due to the limited number of interviewees, and minimal data on textile waste generation, conclusions have been drawn with little information within the study boundary. However, this was mitigated because three different locations for data collection at markets in Dar es Salaam were chosen, and the interviewees gave similar answers independently of each other. Hence, the number of interviews conducted still seems representative. A second factor that influenced the discussions was that they were born in Kiswahili and translated into English by a chemical and process engineering student from Dar es Salaam University. Conclusively, a more comprehensive study of textile waste generation at the market level could provide more detailed insights.

The study posed several challenges concerning official data. Firstly, official and current data from Tanzania's National Bureau of Statistics regarding collection rates and the composition of waste to assess pre-consumer and post-consumer textile waste flows could not be obtained. Attempts were made to circumvent this using official Tanzanian

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU Bibliothek Your knowledge hub WIEN

policy document data and data from non-governmental organisations. Secondly, data regarding secondhand clothing are generally poor available. The Harmonised Commodity Description and Coding System (Harmonised System or HS), developed by the World Customs Organisation (WCO) and applied in international trade, records secondhand clothing under HS code 6309. However, this digit covers all types of used clothing, including footwear, accessories, home textiles, and toys. In addition, fabrics are recorded under different HS codes depending on the material. Thirdly, there is a tendency to underreport the figures (Brooks, 2019). Finally, the HS system does not capture the illegal activities in the secondhand clothing sector, which are usually significant in this area (Brooks, 2013).

Moreover, the United Nations Industrial Development Organisation's records of the African clothing industry performance have many missing forms (ODI, 2017). Attempts were made to circumvent this using official data from Tanzanian Ministries and policy document data. However, the precision of this data is unclear.

Overall, the results of the research gave rise to further questions. An improved data situation could contribute to evaluating the potential of reuse and recycling options for textile waste in a more comprehensive and detailed way. The findings of this study are summarised in the final section. In addition, an outlook is given about expected changes soon.

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

5. Conclusion and outlook

This study has argued that Tanzania's rapid population growth trend, purchasing power increase, and the profound transformations in production and trade of the global textile value chain have resulted in augmenting textile waste generation, mainly by industrial and post-consumer activities. However, the extent of the various waste streams is challenging to determine due to the incomplete data situation.

In particular, the research demonstrated that the considerable gaps in textile waste-related legislation and policy, human, financial, technical and technological limitations and, overall, the lack of awareness in this area restrict reuse and recycling options for textile waste and hinder sound ecologically-friendly disposal.

Taking Dar es Salaam as a reference point, the general waste management system cooperates with CBOs and the informal sector to overcome human, financial and geographical constraints. As a result, the system proves to be partly efficient; however, the absence of clear and well-defined regulations regarding textile waste is symptomatic of its management. There is no systematic or commercial solution despite practised downcycling options for textile waste in the carpentry, automobile, or furnishing industry. The study further revealed unsound practices of textile waste management, such as dumping or burning due to the lack of other disposal options.

As a result, the various reuse and recycling options for textile waste are limited. Reuse and repair options prove most beneficial to the circumstances and environment in Tanzania and effectively prevent waste in the first place. Creating awareness of reuse options could present a vital push factor. In addition, the capacity in low labour costs and the informal sector could be used to develop the branch.

Recycling in common sense, however, is only possible with foreign investment. Moreover, it should be borne in mind that a holistic approach is needed to overcome disagreements on the textile recycling issue. In the case of low-income countries such as Tanzania, recycling should include upcycling to allow for new commercial applications on a large scale. A continental approach is already on its way. The African Circular Economy Alliance, a government-led circular economy coalition of African countries, envisages this goal by supporting the 'Recycled garments industry'. In this sense, it provides measures and standards that enable the upcycling of secondhand goods to allow commercial export to foreign markets (CUTS, 2022).

However, it is somewhat ironic that a continentally driven upcycling initiative is trying to get a grip on the sheer masses of secondhand clothing the African continent is facing.

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU Bibliothek Your knowledge hub WIEN

After all, it highlights the problems of the global fashion value chain and the associated environmental injustice of textile pollution. In addition, it reveals the systemic difficulty that is inherent to it.

While it is essential to prioritise the textile apparel sector to embed more sustainable production and consumption patterns to guarantee a resource-efficient environment, build resilient communities, and contribute to SDG 12, it has to be acknowledged that low-income countries are disproportionally affected by the textile waste issue.

"We are reaching a point where there is a lot more awareness that there are issues in the textile industry, but waste generation has not slowed at all," a global health researcher notes. However, *"we are not going to recycle our way out of this problem"* (Lundberg, 2022). Therefore, fundamental changes in the global textile apparel value chain and a more thoughtful approach to consumerism are necessary.

The results of this study may serve as an orientation tool in textile-relevant policy and legislation. Moreover, this study comprehensively illustrated the potential for further research extensions to contribute to achieving SDG 12 and halt environmental harm effectively.

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

Bibliography

Abimbola, O. 2012. *The International Trade in Secondhand Clothing: Managing Information Asymmetry between West African and British Traders.* Textile 10/2. Available at: https://doi.org.10.2752/175183512X13315695424310

African Union. 1991. *Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa.* Bamako: African Union. Available at: https://au.int/sites/default/files/treaties/7774-treaty-0015_-_bamako_convention_on_hazardous_wastes_e.pdf [Accessed 15-06-2022]

AGOAinfo. 2022. *Trade Profiles Tanzania.* Available at: https://agoa.info/profiles/tanzania.html [Accessed 08-05-2022]

Aus, R., Moora, H., Vihma, M., Unt, R., Kiisa, M. and S. Kapur. 2021. *Designing for circular fashion: integrating upcycling into conventional garment manufacturing processes.* Fashion and Textiles 8, 34. Available at: https://doi.org/10.1186/s40691-021-00262-9

Austrian fibre expert. 20 May 2022. *Transcript_6* [Personal communication].

Basel. 2022. *Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.* Available at: http://www.basel.int/?tabid=4499 [Accessed 19-05-2022]

Boston University. *Environmental health.* Available at: https://www.bu.edu/sph/news/articles/2022/reducing-textile-pollution-through-research-and-art/ [Accessed 02-06-2022]

Brooks, Andrew. 2013. *Stretching global production networks: The international second-hand clothing trade.* Geoforum. Available at: http://dx.doi.org/10.1016/j.geoforum.2012.06.004

Brooks, Andrew and David Simon. 2012. *Unravelling the Relationship between Used-Clothing Imports and the Decline of African Clothing Industries.* Development and Change 43, 6. Available at: https://doi.org/10.1111/j.1467-7660.2012.01797.x

Brooks, Andrew. 2019. *Clothing Poverty: The Hidden World of Fast Fashion and Second-Hand Clothes*. London: Zed Books Ltd

CUTS International Geneva. 2022. *Note: Shifting Towards Circular Policy Framework in Developing Countries.* Available at: https://www.cuts-geneva.org/pdf/KP2022-RRN-Shifting_Towards_Circular_Policy_Frameworks_in_Developing_Countries.pdf [Accessed 24-05-2022]

Dar es Salaam City Council. 2022. *About Us.* Available at: http://www.dcc.go.tz/ [Accessed 21-05-2022]

Directorate-General TRADE. *European Commission.* Available at: https://trade.ec.europa.eu/doclib/docs/2017/february/tradoc_155363.02%20Economic%20Impact%20of%20the%20EU%20-%20EAC%20EPA.pdf [Accessed 08-05-2022]

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.

East Africa Community Secretariat. 2017. *EAC Industrial Competitiveness Report 2017.* Available at: https://www.eac.int/press-releases/149-industrialization-sme-development/891-eac-unveils-industrial-competitiveness-report-2017 [Accessed 07-05-2022]

Ellen MacArthur Foundation. 2017. *A new textiles economy: Redesigning fashion's future.* Available at: https://ellenmacarthurfoundation.org/a-new-textiles-economy [Accessed 11-04-2022]

Ellen MacArthur Foundation. 2022. *Circular Economy Introduction.* Available at: https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview#:~:text=The%20circular%20economy%20is%20a,do%20with%20the%20materials%20afterwards. [Accessed 09-05-2022]

Ellen MacArthur Foundation. 2022. *Recycling and the circular economy: what's the difference?* Available at: https://ellenmacarthurfoundation.org/articles/recycling-and-the-circular-economy-whats-the-difference [Accessed 10-05-2022]

European Commission. 2020. *COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A new Circular Economy Action Plan For a cleaner and more competitive Europe.* COM/2020/98 final. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020DC0098&from=EN [Accessed 30-05-2022]

European Commission. 2020. *COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Closing the loop - An EU action plan for the Circular Economy.* COM/2015/0614 final. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52015DC0614&from=EN [Accessed 30-05-2022]

European Commission. 2020. *Special Eurobarometer 501. Attitudes of European citizens towards the Environment.* Available at: https://europa.eu/eurobarometer/surveys/detail/2257 [Accessed 11-05-2022]

European Commission. 2022. *Waste Framework Directive.* Available at: https://ec.europa.eu/environment/topics/waste-and-recycling/waste-framework-directive_en [Accessed 01-06-2022]

European Commission. 2022a. *Green Deal: New proposals to make sustainable products the norm and boost Europe's resource independence.* Available at: https://ec.europa.eu/commission/presscorner/detail/en/ip_22_2013 [Accessed 10-05-2022]

European Commission. 2022b. *COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS On making sustainable products the norm.* COM/2022/140 final. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0140&qid=1649112555090

European Environment Agency. 2019. *Textiles in Europe's circular economy. EEA briefing no 10/2019.* Available at:

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

https://www.eea.europa.eu/downloads/e27564dbf0f7462ea5c52e4c9aaf2775/1615301143/textiles-in-europe-s-circular-economy.pdf [Accessed 04-05-2022]

European Environment Agency. 2022a. *Textiles and the environment: the role of design in Europe's circular economy. EEA briefing no 1/2022.* Available at: https://www.eea.europa.eu/publications/textiles-and-the-environment-the [Accessed 04-05-2022]

European Environment Agency. 2022b. *Microplastics from textiles: towards a circular economy for textiles in Europe.* Available at: https://www.eea.europa.eu/publications/microplastics-from-textiles-towards-a [Accessed 08-05-2022]

European Man-Made Fibres Association (CIRFS). 2022. *Key Statistics.* Available at: https://www.cirfs.org/statistics/key-statistics [Accessed 24-04-2022]

European Parliament. 2008. *Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives.* Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32008L0098&from=EN [Accessed 30-05-2022]

European Parliament. 2014. *Workers' conditions in the textile and clothing sector: Just an Asian affair? Issues at stake after the Rana Plaza tragedy.* Available at: https://www.europarl.europa.eu/EPRS/140841REV1-Workers-conditions-in-the-textile-and-clothing-sector-just-an-Asian-affair-FINAL.pdf [Accessed 13-05-2022]

European Parliament. 2018. *Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste.* Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32018L0851&from=EN [Accessed 13-04-2022]

European Parliament. 2020. *European Parliament resolution of 15 January 2020 on the European Green Deal (2019/2956(RSP)).* Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020IP0005&from=EN [Accessed 13-04-2022]

European Parliament. 2022. *The impact of textile production and waste on the environment.* Available at: https://www.europarl.europa.eu/news/en/headlines/society/20201208STO93327/the-impact-of-textile-production-and-waste-on-the-environment-infographic [Accessed 10-05-2022]

Fachverband Textilrecycling bvse. 2020. *Bedarf, Konsum, Wiederverwendung und Verwertung von Bekleidung und Textilien in Deutschland.* Available at: https://www.bvse.de/dateien2020/1-Bilder/03-Themen_Ereignisse/06-Textil/2020/studie2020/bvse%20Alttextilstudie%202020.pdf [Accessed 15-05-2022]

Food and Agriculture Organization of the United Nations and International Cotton Advisory Committee. 2013. *World apparel fibre consumption survey.* Available at: http://sewitagain.com/wp-content/uploads/2013/12/FAO-ICAC-Survey-2013-Update-and-2011-Text.pdf [Accessed 15-05-2022]

Gibbon, P. 1996. Zimbabwe: 1991–1994 In *Limits of Adjustment in Africa: The Effects of Economic Liberalization, 1986–1994, 353–97,* edited by P. Engberg- Pedersen, P. Gibbon, P. Raikes and L. Udsholt. Copenhagen: Centre for Development Research/ James Currey/Heinemann

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

Greenpeace. 2012. *Toxic Threads: The Big Fashion Stich-Up.* Available at: https://www.greenpeace.org/international/publication/6889/toxic-threads-the-big-fashion-stitch-up/ [Accessed 17-05-2022]

Hansen, K.T. 2008. Charity, Commerce, Consumption: The International Second-hand Clothing Trade at the Turn of the Millennium—Focus on Zambia In *Alternative Exchanges: Secondhand Circulations from the Sixteenth Century to the Present*, edited by L. Fontaine, 221–34. New York and Oxford: Berghahn Books

Hussein, O. 2020. *Assessment of the Refuse Collection Charges in Covering Waste Management Cost: The Case of ILALA Municipality -Dar Es Salaam, Tanzania.* Available at: https://www.researchgate.net/publication/343500556_Assessment_of_the_Refuse_Collection_Charges_in_Covering_Waste_Management_Cost_The_Case_of_ILALA_Municipality_-Dar_Es_Salaam_Tanzania [Accessed 21-05-2022]

Hussein, O. and B. Saphy. 2021. *Analysing the Compliance of the National Solid Waste Management Related Legislations in Selected Local Gorvernment Authorities in Tanzania.* National Journal of Environmental Law Vol. 4/1. Available at: https://doi.org/1037591/NJEL

Houck, Max M. 2009. Identification of Textile Fibres In *Woodhead Publishing Series in Textiles,* edited by Max M. Houck. Cambridge: Woodhead Publishing Limited and CRC Press LLC.

Industrial Analytics Platform UNIDO. 2022. *The Circular Economy: From waste to resource through international trade.* Available at: https://iap.unido.org/articles/circular-economy-waste-resource-through-international-trade [Accessed 22-05-2022]

International Labour Organisation, Employment Analysis Unit. 2005. *The end of the Multi-Fibre Arrangement and its implications for trade and employment.* Available at: https://ilo.org/wcmsp5/groups/public/---ed_emp/---emp_elm/documents/publication/wcms_114030.pdf [Accessed 13-05-2022]

International Labour Organisation and United Nations Children's Fund. 2021. *Child Labour: Global estimates 2020, trends and the road forward.* Available at: https://www.ilo.org/wcmsp5/groups/public/---ed_norm/---ipec/documents/publication/wcms_797515.pdf [Accessed 21-05-2022]

Kabir, S.M.F., Chakraborty, S., Hoque, S.M.A., and K. Mathur. 2019. *Sustainability assessment of cotton-based textile wet processing.* Cleanroom Technology 1, 232–246. Available at: https://doi.org/10.3390/cleantechnol1010016

Karthik, T. and D. Gopalakrishnan. 2014. Environmental Analysis of Textile Value Chain: An Overview In *Roadmap to Sustainable Textiles and Clothing Technology.* Singapore: Springer Science Business Media.

Kasper, M., and E. Stroomer. 2021. *Multiplying textile lives, Textile collection recycling in urban Africa.* Agathon- International Journal of Architecture, Art and Design 09/21, 224-231. Available at: https://doi.org/10.19229/2464-9309/9222021

Khan, M.M.R., and M.M. Islam. 2015. *Materials and manufacturing environmental sustainability evaluation of apparel product: knitted T-shirt case study.* Textiles and Clothing Sustainability 1, 8. Available at: https://doi.org/10.1186/s40689-015-0008-8

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

Kolanjikombil, M. 2018. *Handbook of Textile Processors Series. The Substrates – Fibres, Yarn and Fabrics.* New Delhi: Woodhead Publishing India Pvt. Ltd.

Koszewska, M. 2018. *Circular Economy – Challenges for the Textile and Clothing Industry.* AUTEX Research Journal. 18/4, 337-347. Available at: https://doi.org/10.1515/aut-2018-0023

Koszewska, M. 2019. Circular economy in textiles and fashion - the role of a consumer In *Circular Economy in Textiles and Apparel.* Elsevier 183-206. Available at: https://doi.org/10.1016/B978-0-08-102630-4.00009-1

Leslie, Heather A., and Marja H. Lamoree. 2022. *Discovery and quantification of plastic particle pollution in human blood.* Environment International vol. 163. Available at: https://doi.org./10.1016/j.envint.2022.107199 [Accessed 19-05-2022]

McKinsey. 2016a. Center for Business and Environment. *The circular economy: Moving from theory to practice*. Available at: https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Sustainability/Our%20Insights/The%20circular%20economy%20Moving%20from%20theory%20to%20practice/The%20circular%20economy%20Moving%20from%20theory%20to%20practice.ashx [Accessed 04-05-2020]

McKinsey. 2016b. *Style that's sustainable: A new fast-fashion formula.* Available at: https://www.mckinsey.com/business-functions/sustainability/our-insights/style-thats-sustainable-a-new-fast-fashion-formula [Accessed 18-05-2022]

McKinsey. 2021. *State of the Fashion Report 2022.* Available at: https://www.mckinsey.com/~/media/mckinsey/industries/retail/our%20insights/state%20of%20fashion/2022/the-state-of-fashion-2022.pdf [Accessed 14-05-2022]

METL Group. 2022. *METL Group.* Available at: https://www.metl.net/ [Accessed 07-05-2022]

Ministry of Industry, Trade and Investment. 2016. *Tanzania Industrial Competitiveness Report 2015 (TICR).* https://www.unido.org/sites/default/files/2016-05/TICR_Summary_Report_-_FINAL_25Apr16_0.pdf [Accessed 07-05-2022]

Naidoo, K. and L. Ndikumana. 2020. *Unit Labor Costs and Manufacturing Sector Performance in Africa.* UMass Economics Working Papers. 293. Available at: https://doi.org/10.7275/19042210

Nayak, R., Akbari, M., and S. Maleki Far. 2019. *Recent sustainable trends in Vietnam's fashion supply chain.* Journal of Cleaner Production 225, 291–303. Available at: https://doi.org/10.1016/j.jclepro.2019.03.239

Onimode, B. 1988. *A Political Economy of the African Crisis*. London: Zed Books

Overseas Development Institute. 2017. The phase-out of second-hand clothing imports: what impact for Tanzania?. Available at: https://mpra.ub.uni-muenchen.de/82175/ [Accessed 07-05-2022]

Piribauer B. and A. Bartl. 2019. Textile Recycling processes, state of the art and current developments: A mini review In *Waste Management and Research 37, 2.* Available at: https://doi.org/10.1177/0734242X18819277

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU Bibliothek Your knowledge hub WIEN

Quantis. 2018. *Measuring Fashion. Environmental Impact of the Global Apparel and Footwear Industries Study.* Available at: https://quantis-intl.com/wp-content/uploads/2018/03/measuringfashion_globalimpactstudy_full-report_quantis_cwf_2018a.pdf [Accessed 14-05-2022]

Sandin, Gustav and Greg M. Peters. 2018. *Environmental impact of textile reuse and recycling – A review.* Journal of Cleaner Production 184, 353-365. Available at: https://doi.org/10.1016/j.jclepro.2018.02.266

Swedish Chemicals Agency KEMI. 2014. *Chemicals in textiles – Risks to human health and the environment. Report 6/14.* Available at: https://www.kemi.se/download/18.6df1d3df171c243fb23a98f3/1591454110491/rapport-6-14-chemicals-in-textiles.pdf [Accessed 18-05-2022]

Statista. 2022. *The 20 countries with the highest population growth rate in 2021.* Available at: https://www.statista.com/statistics/264687/countries-with-the-highest-population-growth-rate/ [Accessed 14-05-2022]

Tanzanian engineering expert. 3 January 2022. *Transcript_1* [Personal communication].

Tanzanian environmental entrepreneur expert. 30 March 2022. *Transcript_3* [Personal communication].

Tanzanian environment expert. 17 May 2022. *Transcript_4* [Personal communication].

Tanzanian non-governmental expert. 22 January 2022. *Transcript_2* [Personal communication].

Tanzanian recycling expert. 19 May 2022. *Transcript_5* [Personal communication].

Textile Development Unit Tanzania, Ministry of Industry, Trade and Investment. 2022. *Textile Development Unit Tanzania.* Available at: https://tdu.or.tz/investing-in-tanzania/ [Accessed 07-05-2022]

The Observatory of Economic Complexity (OEC). 2022. *Used Clothing.* Available at: https://oec.world/en/profile/hs/used-clothing [Accessed 02-05-2022]

The World Bank. 2018. *What a Waste 2.0, A Global Snapshot of Solid Waste Management to 2050.* Available at: https://openknowledge.worldbank.org/handle/10986/30317 [Accessed 16-05-2022]

The World Bank Data. 2022. *Population Tanzania.* Available at: https://data.worldbank.org/indicator/SP.POP.TOTL?locations=TZ [Accessed 13-05-2022]

Traub-Merz, R. 2006. The African Textile and Clothing Industry: From Import Substitution to Export Orientation In *The Future of the Textile and Clothing Industry in Sub-Saharan Africa, 9–35.,* edited by H. Jauch and R. Traub-Merz. Bonn: Friedrich-Ebert-Stiftung

Umweltbundesamt. 2022. *Aufkommen und Behandlung von Textilabfällen in Österreich. Materialien zum Bundes-Abfallwirtschaftsplan.* Available at: https://www.umweltbundesamt.at/fileadmin/site/publikationen/rep0788.pdf [Accessed 11-05-2022]

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

United Nations. 1945. *The Charter of the United Nations.* San Francisco: United Nations. Available at: https://treaties.un.org/doc/publication/ctc/uncharter.pdf [Accessed 15-06-2022]

United Nations. 1989. *The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal.* Basel: United Nations. Available at: https://www.basel.int/Portals/4/Basel%20Convention/docs/text/BaselConventionText-e.pdf [Accessed 15-06-2022]

United Nations Department of Economic and Social Affairs, Population Division. 2018. *World Urbanization Prospects 2018.* Available at: https://population.un.org/wup/Publications/ [Accessed 17-05-2022]

United Nations Department of Economic and Social Affairs, Sustainable Development. *2022.* Available at: https://sdgs.un.org/ [Accessed 21-05-2022]

United Nations Alliance for Sustainable Fashion. *2021.* Available at: https://unfashionalliance.org/ [Accessed 14-05-2022]

United Nations. 2022. *Treaties.* Available at: https://treaties.un.org/pages/showDetails.aspx?objid=080000028009385c [Accessed 19-05-2022]

United Nations Data. 2022. *The United Republic of Tanzania.* Available at: https://data.un.org/en/iso/tz.html [Accessed 14-05-2022]

United Nations Environment Programme. 2022. *African Ministerial Conference on the Environment.* Available at: https://www.unep.org/regions/africa/african-ministerial-conference-environment [Accessed 24-05-2022]

United Nations Institute for Training and Research. 2022. *Stop open waste burning.* Available at: https://stopopenburning.unitar.org/ [Accessed 21-05-2022]

United Republic of Tanzania. 1977. *Constitution of the United Republic of Tanzania.* Available at: https://rsf.org/sites/default/files/constitution.pdf [Accessed 30-05-2022]

United Republic of Tanzania. 1982. *Local Government (Urban Authorities) Act No. 8.* Available at: https://procedures.tic.go.tz/media/The_local_government_urban_authorities_act_8-1982.pdf [Accessed 30-05-2022]

United Republic of Tanzania. 2004. *The Environmental Management Act.* Available at: https://www.nemc.or.tz/uploads/publications/sw-1576228517-ema%20act2004.pdf [Accessed 30-05-2022]

United Republic of Tanzania. 2009. *The Environmental Management (Solid Waste Management) Regulations of 2009.* Available at: https://www.eaco.int/admin/docs/reports/TZ-04_Solid-Waste-Regulations-Revised-January_2009_ver1_2.pdf [Accessed 30-05-2022]

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

United Republic of Tanzania. 2011. *The Public Procurement Act 2011.* Available at: https://www.ppra.go.tz/95-legislation/140-public-procurement-act-2011 [Accessed 30-05-2022]

United Republic of Tanzania. 2013. *The Public Procurement Act Regulations of 2013.* Available at: https://www.ppra.go.tz/phocadownload/attachments/Regulations/regulations2013.pdf [Accessed 30-05-2022]

United Republic of Tanzania. 2009. *The Public Health Act of 2009.* Available at: https://www.ilo.org/dyn/natlex/docs/ELECTRONIC/86526/97739/F1426061991/TZA86526.pdf [Accessed 30-05-2022]

United Republic of Tanzania. 2018. *National Solid Waste Management Strategy.* Available at: https://wedocs.unep.org/bitstream/handle/20.500.11822/31292/NWMS_Tanzania.pdf?sequence=1&isAllowed=y [Accessed 30-05-2022]

World Bank Group. 2022. *Solid Waste Management.* Available at: https://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management [Accessed 16-05-2022]

World Health Organisation. 2019. *Progress on drinking water, sanitation and hygiene 2000-2017: Special focus on inequalities.* Available at: https://www.unicef.org/media/55276/file/Progress%20on%20drinking%20water,%20sanitation%20and%20hygiene%202019%20.pdf [Accessed 14-05-2022]

World Trade Organisation. 2021. *World Trade Statistical Review 2021.* Available at: https://www.wto.org/english/res_e/statis_e/wts2021_e/wts21_toc_e.htm [Accessed 07-05-2022]

World Wildlife Fund. 2022. *Sustainable Agriculture Cotton.* Available at: https://www.worldwildlife.org/industries/cotton [Accessed 08-05-2022]

Zaidi Recyclers. 2022. *Taka-na-ajira initiative.* Available at: https://zaidi.co.tz/ [Accessed 20-05-2022]

Zhang, M., Kong, X.X., and S.C. Ramu. 2016. *The transformation of the clothing industry in China.* Asia Pacific Business Review 22, 86–109. Available at: https://www.researchgate.net/publication/269808614_The_Transformation_of_the_Clothing_Industry_in_China [Accessed 15-06-2022]

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

List of Tables

Table 1: Analysis of the interview transcripts 13
Table 2: Production waste generated during textile-apparel manufacturing 22
Table 3: Recycling routes, adapted from the report ‘A New Textiles Economy’ 24

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub

List of Figures

Figure 1: Total global fibre production output.....16
Figure 2: Diagram of global material flows for clothing in 2015.....24
Figure 3: Schematic representation of the circular economy model.....28
Figure 4: A secondhand vendor at a local Dar es Salaam market 39
Figure 5: Waste management hierarchy in Tanzania's Waste Management Strategy (1998).....41
Figure 6: The concept of the waste hierarchy in the WFD (2008) 43
Figure 7: Textile material waste from a tailoring workshop in the municipality of Ilala in Dar es Salaam 51
Figure 8: Outside area of a tailoring workshop in the municipality of Ilala in Dar es Salaam.....52
Figure 9 : Dumped textiles in various forms, including clothing, interior items and footwear in Dar es Salaam. 54
Figure 10: Manzese Tandale secondhand market in Dar es Salaam.....56
Figure 11: A stall specialising in men's trousers at Ilala market in Dar es Salaam. 56
Figure 12: A female tailor at Ilala market in Dar es Salaam. 57

Die approbierte gedruckte Originalversion dieser Masterarbeit ist an der TU Wien Bibliothek verfügbar.
The approved original version of this thesis is available in print at TU Wien Bibliothek.
TU WIEN Bibliothek Your knowledge hub