'Textile Waste and Circular Economy in Nigeria: Lessons from Kaduna and Policy Opportunities for Edo State" Structure'

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ABSTRACT

The global textile and fashion industry produces more than 92 million tons of waste products every year and thus is considered one of the most harmful industries to the environment. In Nigeria, the once-prosperous textile industry in Kaduna has left a social-environmental scar, and Edo State is becoming an emerging model in terms of fashion and textile activities. This contrast shows not only the

dangers of unsustainable industrialization but also a chance that Edo has to embrace the concept of the circular economy at the very beginning.

The current study uses systematic literature review (2000-2024) with PRISMA 2020 guidelines, incorporating environmental, socio-economic, and policy perspectives. It has been demonstrated that the governance of the textile waste in Nigeria is limited by the infrastructural gaps, policy inconsistencies, and lack of integration of the informal sector. The downfall of Kaduna demonstrates the price of disregarding sustainability, and Edo offers an opportunity to become the first to follow circular routes, relying on the examples of other international models like Extended Producer Responsibility, upcycling, and digital traceability.

Main findings indicate: (i) continued governance weaknesses; (ii) policy coherence structural constraints; (iii) failure to exploit informal knowledge; and (iv) knowledge gaps in gender effects, long-term policy review and technology transfer. Policy implications also highlight the necessity of institutional reform, building capacity and new forms of governance that can bridge international best practices and local realities. Edo has the potential to become the policy lab of circular fashion in Africa, contributing to the development of Nigeria towards SDGs 6, 8, 12, and 13.

CHAPTER 1. FURTHER CONTEXT AND AIMS

Background

The textile and fashion industry is one of the most polluting industries globally producing more than 92 million tons of waste annually. The disintegration of the former high performing textile industry in Kaduna has created long term socio-environmental impacts in the country while Edo State is becoming the possible centre of fashion and textile economic activity. This contrast outlines the dangers of the unsustainable industrial paths and the chances to introduce the principles of the circular economy at the inception of the sector development.

Objectives

The paper will be a systematic meta-analysis that aims to:

(i) synthesize existing evidence of textile waste production, environmental impacts and socio-economic consequences in Nigeria
(ii) derive historical lessons on the rise and fall of industrialization in Kaduna
(iii) respond to the question of whether Edo State is ready to adopt a circular economy and
(iv) create evidence-based and context-specific policy recommendations.

Methods of Meta-Analysis

The literature review of 2000-2024 was performed in Scopus, Web of Science, AJOL, JSTOR, and grey

literature repositories in accordance with the PRISMA 2020 requirements. The inclusion/exclusion criteria were used to screen studies and data extraction was informed by environmental-socioeconomic-policy analytical triad. Narrative synthesis was used to supplement comparative case analysis since there was heterogeneity of evidence (Kaduna vs. Edo). The time frame was used to capture the post-industrial degradation of Kaduna as well as the modern rise of the creative economy of Edo.

Key Findings

It has been evidenced that the textile waste regulation in Nigeria is limited due to the lack of infrastructures, regulatory inconsistency and the poor integration of the informal sector players. The failure of Kaduna would portray the systemic expenditures of the policy inconsistency, outdated technology and environmental insensitivity, and Edo would offer an uncommon policy window to internalize circularity. Extended Producer Responsibility, reuse and upcycling systems and digital traceability, are global models that can only be transferred to a local socio-political and infrastructural reality. There are still major gaps in policy evaluation on a long-term basis, gendered aspects of textile circularity and technology transfer to developing economies.

Policy Implications

The discussion highlights the need to have multi-level governance reform, institutional capacity building as well as hybrid systems that make informal sector expertise an asset. The framework of a policy lab of circular fashion in Africa based on climate finance and south-south cooperation may be applied to Edo State and scale contextually adequate innovations. A focus on the development of textile circularity will also unburden Nigeria of its environmental pressures, enhance the resilience of industries and increase the development of SDGs 6, 8, 12 and 13.

CHAPTER 2: INTRODUCTION

2.1 Global Context of Textile and Fashion Waste

The textile and clothing industry is one of the most environmentally challenging sectors and is characterised by the fact that it is the major contributor of wastes and depletion of resources. According to modern studies, the sector generates more than 92 million tons of textile waste per year on a global scale, most of which is burnt down or put in landfills, resulting in a significant contribution to greenhouse gasses, ground and water pollution, as well as an overall ecosystem damage (ACS Omega, 2024). This increasing environmental strain has fueled demands to put in place sustainable methods of producing textile and managing waste.

The standard production model that has prevailed in the textile sector, characterised by the take-make-dispose model has become increasingly unsustainable as global consumption trends continue to increase. Studies show that the textiles are deposited in the landfills at a very high rate of 1 garbage truck per second and this rate poses great environmental risks should the current trends persist (Circular Economy and Sustainability, 2021). This crisis has required a paradigm shift to the principles of a circular

economy, which recommends the elimination of waste, maintenance of products and materials in use, and regeneration of natural systems.

The circular economy approach provides avenues that can be used to deal with textile wastes in four major activities: removals of wastes during the design phase, product life cycle, reuse and recycling of materials, and renewal of natural resources (ResearchGate, 2023). Chemical and biotechnological processes have been promising especially with acid hydrolysis recovery of glucose up to 70% and enzymatic recycling consuming a quarter of the energy of conventional processes. These inventions highlight the technical capability of changing the linear to a circular system in the production of textiles.

2.2 Nigeria's Textile Landscape: Kaduna's Historical Legacy and Edo's Emerging Industry

The textile industry of Nigeria is a good case study to consider the opportunities and challenges of implementing the textile waste management and the circular economy. The textile industry in the country has experienced tremendous changes during the last seven decades and the regional developmental trends and degradation deserve serious consideration as they provide certain lessons to the modern policy-makers.

The Kaduna State can be called the epicenter of the textile manufacturing industry in Nigeria. In 1955, government officials in the northern part of Nigeria in coordination with the British textile company David Whitehead and Sons were able to make arrangements to construct the very first large scale textile producing plant in the area (Textile History, 2013). This project was the starting point of what was to emerge as an industrial powerhouse, as the production of textiles, spinning and dyeing activities grew considerably throughout the oil boom of the seventies.

The magnitude of the success of the Nigerian textile industry when it was at its peak was extraordinary. The industry boomed unexpectedly between 1970 and 1987, whereby the demand of the products surpassed the supply by 91% (SimplVest, 2025). At its peak, the industry had more than 350,000 direct workers and millions of indirect jobs and was therefore the biggest labor employer after the government (ResearchGate, 2016). By the year 1984, it had 175 textile industries in operation in Nigeria and the industry had 22% of all manufacturing jobs (UNESCO, 2021).

But this golden age was succeeded by a downward plunge. In 1997, the leading textile corporations, such as Kaduna Textiles Limited (KTL) Arewa textile and United Nigerian Textile Limited (UNTL) were hardly operating on old machinery, with no money to buy spare parts in addition to facing irregular electricity supply (ResearchGate, 2013). This crisis was blamed on various reasons such as inconsistency in the policies, infrastructural problems, competition due to imported textiles and the extensive macro economic instability.

In modern Nigeria, the situation is different, the fashion and textile business now occupies the second-largest place in Africa, with Nigeria contributing to 15% of the total volume on the continent (Commonwealth Roundtable, 2024). However, this revival is characterised more by fashion designing and garment assembly than mass production of textiles. With the state of Edo becoming a kind of hotspot of

the new wave of textile and fashion industry development, it is an opportunity to apply the principles of the circular economy at the very beginning instead of modifying the current linear systems.

2.3 Rationale for a Meta-Analysis Approach

The choice of a meta-analysis methodology in this study is informed by a number of strong reasons that fall under the same umbrella of the complexity of the research questions as well as the nature of the evidence that can be retrieved in the environmental context of textile waste management in Nigeria. Meta-analysis is a methodical way of bringing together all already available literature, policy reports, case studies and empirical evidence to come up with holistic information that may not be reflected in single studies.

The fragmented nature of textile waste studies in Nigeria makes the meta- analysis approach necessary in order to unify various sources of information. Since the textile waste management practices in different regions, industrial levels, and policy environments may differ considerably in Nigeria, a meta-analysis can be used to systematize the results of multiple contexts to see the patterns, gaps, and opportunities that may not be evident through individual case studies.

Moreover, the rapid change in the concept of the circle economy and its implementation in the context of developing countries necessitates an approach that can combine theoretical frameworks and practical implementation experience. Meta-analysis allows developing the research to connect the global principles of the circular economy with the local situations in Nigeria with references to both the local history of Kaduna and the new trends observed in states such as Edo.

It is also essential in applying the methodology to policy-related questions because the questions can be systematically evaluated to establish the best practices regarding the textile waste management process and draw evidence-based recommendations. This comes in handy particularly in the Nigerian context where policy formulation is mostly done with little access to the detailed empirical information.

Also, the meta-analytical methodology is used to solve the problem of insufficient availability of primary data in most areas of textile waste management in Nigeria. Through systematic surveys and syntheses of existing literature, case analysis, policy reports, and industry reports, the study will be able to produce strong findings although there are limited primary data collection opportunities.

2.4 Research Objectives and Guiding Questions

This study is designed based on four main objectives, which together, will answer the multifaceted challenges and opportunities of textile waste management and the implementation of the circular economy in Nigeria, with specific references to the experience of Kaduna and the policy opportunities of Edo State.

The initial goal is to carry out a thorough examination of the trends of textile waste production, waste management systems, and environmental effects in Nigeria and the focus on the understanding of the magnitude and nature of waste issues. The analysis aims to address the underlying question: What are the

prevailing trends and magnitudes of textile waste production in various industries of the Nigerian textile and fashion value chain, and what do the current waste management systems mean to the environment and socioeconomic status?

The second goal is on deriving and generalizing what the textile industry in Kaduna has learned both in the course of its expansion and its eventual downfall. The purpose of this historical analysis is to answer the question: What can be learnt about the Kaduna textile industry trajectory about what makes a textile waste management and circular economy practices successful, and what can be learned about the factors that make textile waste management and circular economy practices successful and how can the lessons be applied to the contemporary policy formulation?

The third goal is to evaluate the level of circular economy preparedness in the Nigerian textile industry, and especially within the Edo State. This evaluation will be informed by the following question: What are the existing opportunities, challenges, and potentials of applying the principles of the circular economy to the textile industry in Nigeria, and how can they be used to build effective waste management solutions in Edo State?

The fourth and the last goal is to come up with evidence based policy recommendations that can help to move toward the circular economy practice in textile waste management. This objective responds to the following question: What policy interventions, institutional arrangements, and support mechanisms are required to facilitate the successful adoption of circular economy strategies to manage textile waste in Nigeria, especially in emerging textile centres such as Edo State?

These research objectives are linked, and structured to lead out of each other, forming an in-depth perspective on the challenges and opportunities of the textile waste situation in Nigeria. The guiding questions not only offer a structure in which a systematic investigation is possible, but also keep in mind the focus on policy-relevant outcomes that could help to achieve sustainable development in the textile sector in Nigeria.

The study methodology acknowledges that the management of textile waste cannot be considered independently of more general issues of industrial policy, environmental policy, and economic development policy. That is why the scope of the investigation is not only the technical side of waste management and the implementation of the circular economy but also the institutional policy contexts and socioeconomic factors that determine the viability and effectiveness of various methods of managing textile waste in the Nigerian environment.

CHAPTER 3: METHODOLOGY

3.1 Meta-Analysis Design

The study adopts a systematic meta-analytical methodology to review textile waste management and circular economy application in Nigeria with specific emphasis on distilling lessons learned in the textile industry of Kaduna and policy opportunities in Edo State. The methodology adheres to PRISMA 2020

(Preferred Reporting Items for Systematic reviews and Meta-Analyses) guidelines, which is a standardized template of conducting and reporting systematic reviews and meta-analyses.

The meta-analysis design will involve quantitative and qualitative synthesis methods to support the heterogeneous nature of the evidence available to support the textile waste management in Nigeria. Since there are few strictly comparable quantitative studies in this field, the approach is focused on narrative synthesis with the inclusion of quantitative features in cases where suitable information is available. This mixed-method design is consistent with the current best practices in systematic reviews of complex interventions and policy areas, especially in developing country settings where empirical data might be distributed across multiple sources.

The research design adheres to convergent synthesis model, according to which results obtained with the help of various kinds of studies (case studies, policy analyses, industry reports, and empirical research) will be combined to give a complete idea of the issues and opportunities of the textile waste management. This method acknowledges that effective policy recommendations demand evidence synthesis across numerous domains such as technical feasibility, economic viability, environmental impact, and sociopolitical acceptability.

The meta-analysis timeframe, 2000-2024, spans the decay of the traditional textile sector in Nigeria and the rise of modern fashion and circular economy projects. This period will enable the investigation of long-term trends and represent topicality to contemporary policy settings.

3.2 Literature Search Strategy

The literature search strategy was developed in such a way that it focuses on the scope of the evidence that is present on the topic of textile waste management and circular economy in Nigeria and ensures systematic rigor. The search strategy used both broad and narrow methods, noting that the evidence may be found in different fields of research and in various types of publications.

Database Selection and Rationale

The major academic databases searched are: Scopus, Web of Science, PubMed, JSTOR, Project MUSE and African Journals Online (AJOL). These databases were chosen to cover both international and African-oriented studies. Scopus and Web of Science offer broad coverage of peer-reviewed articles in a variety of fields, whereas AJOL guarantees coverage of research that is regionally-specific and may not be found in international databases. PubMed gathers health and environmental research, whereas JSTOR and Project MUSE give access to literature on social science and policy-oriented literature.

Additional searches were in dedicated repositories such as: ResearchGate grey literature and working papers, Google Scholar extended coverage such as conference papers and reports, OECD iLibrary policy documents and development reports, World Bank Open Knowledge Repository development finance and development policy analysis, and Nigerian institutional repositories such as university repositories that have a strong textile research presence.

Search Terms and Keywords Strategy

The search strategy employed a combination of controlled vocabulary terms and free-text keywords, organised into four primary clusters:

Textile and Fashion Terms: *"textile waste," "fashion waste," "clothing waste," "apparel waste," "textile recycling," "fashion sustainability," "textile industry," "garment industry," "fabric waste," "textile production"*

Circular Economy Terms: *"circular economy," "waste-to-resource," "industrial ecology," "closed-loop systems," "cradle-to-cradle," "resource efficiency," "waste minimization," "sustainable production," "eco-efficiency"*

Geographic Terms: *"Nigeria," "Kaduna," "Edo State," "West Africa," "Sub-Saharan Africa," "developing countries," "emerging economies"*

Policy and Management Terms: *"waste management," "environmental policy," "industrial policy," "sustainable development," "policy analysis," "case study," "lessons learned," "best practices"*

Terms within and among concept clusters were combined using Boolean operators (AND, OR). Each database search was modified to fit search and indexing restrictions by adapting search strings to its respective database.

Time Frame Justification

The search included the literature published in the period between January 2000 and December 2024. The year 2000 was chosen as the starting point to ensure that the period covered includes the time after the big crash of the textile industry in Nigeria in the 1990s yet has adequate time span to provide long-term trends and patterns. The end date will make sure that the latest research and policy developments are included.

3.3 Inclusion and Exclusion Criteria

The study applied systematic inclusion and exclusion criteria developed a priori to ensure consistency and minimize selection bias. These criteria were designed to balance comprehensiveness with relevance to the research objectives.

Inclusion Criteria

Studies, reports, and documents were included if they met the following criteria:

- Focus on textile, clothing, or fashion waste management, circular economy principles, or sustainable textile production
- Geographic relevance to Nigeria, West Africa, or comparable developing country contexts
- Publication or release date between January 2000 and December 2024

- Available in English, French, or with English abstracts
- Contain empirical data, case study analysis, policy analysis, or theoretical frameworks applicable to the research questions
- Include primary research, policy documents, industry reports, conference proceedings, or grey literature with identifiable methodology
- Provide insights relevant to either historical analysis of textile industry development/decline or contemporary circular economy implementation

Exclusion Criteria
Materials were excluded if they:

- Focus exclusively on developed country contexts without transferable insights to developing countries
- Address only theoretical aspects of circular economy without practical application
- Lack clear methodology or are purely opinion-based without supporting evidence
- Are duplicate publications or preliminary versions of subsequently published work
- Focus on textile production techniques without addressing waste management or sustainability
- Are published before 2000 except for historically significant documents specifically related to Nigeria's textile industry
- Are not accessible through institutional subscriptions or open access platforms

Quality Assessment Criteria

Included materials underwent quality assessment using criteria adapted from established frameworks for evaluating diverse evidence types:

- Methodological rigor: Clear description of methods, appropriate methodology for research questions
- Relevance: Direct or transferable relevance to textile waste management and circular economy in Nigeria
- Credibility: Peer review status, institutional affiliation, or established organizational reputation
- Completeness: Sufficient detail to allow for synthesis and interpretation
- Transparency: Clear reporting of limitations and potential biases

3.4 Data Extraction and Categorisation

Data extraction followed a standardized protocol designed to capture both quantitative indicators and qualitative insights relevant to the research objectives. A purpose-built data extraction form was developed and pilot-tested on a sample of included materials before full implementation.

Standardized Data Extraction Elements

For each included source, the following information was systematically extracted:

- Bibliographic details (author, title, publication year, source type)
- Geographic focus and scope
- Methodology employed
- Key findings related to textile waste generation, management practices, and environmental impacts
- Economic data including costs, employment effects, and market dynamics
- Policy recommendations and regulatory frameworks discussed
- Circular economy strategies and implementation experiences
- Barriers and enablers identified for sustainable textile waste management
- Stakeholder perspectives and social dimensions
- Temporal context and historical significance

Thematic Categorisation Framework

Extracted data were categorized using a hybrid deductive-inductive approach, combining predetermined categories derived from circular economy literature with emergent themes identified during the analysis process.

Primary Thematic Categories:

- Waste Generation Patterns: Types, volumes, and sources of textile waste
- Current Management Practices: Existing approaches to textile waste handling and disposal
- Environmental Impacts: Ecological consequences of different waste management approaches
- Economic Dimensions: Cost structures, economic incentives, and market dynamics
- Policy and Regulatory Frameworks: Existing policies, gaps, and recommendations
- Technological Solutions: Recycling technologies, innovation, and technical feasibility
- Social and Cultural Factors: Community practices, cultural attitudes, and social acceptance
- Institutional Arrangements: Organizational structures, partnerships, and governance mechanisms

Secondary Categories by Context:

- Historical Analysis (Kaduna focus): Industrial development, decline factors, lessons learned
- Contemporary Opportunities (Edo focus): Current initiatives, potential interventions, scalability
- Comparative Insights: Cross-regional comparisons and transferable practices

Quality Coding and Reliability

Data extraction was conducted by trained researchers using standardized protocols. A subset of sources (approximately 20%) underwent double extraction to ensure reliability and consistency. Inter-rater agreement was assessed, and discrepancies were resolved through discussion and consensus.

3.5 Analytical Framework

The analytical framework integrates three complementary dimensions - environmental, socio-economic, and policy - to provide comprehensive understanding of textile waste management challenges and circular economy opportunities in Nigeria.

Environmental Dimension Analysis

Environmental analysis focuses on quantifying and characterizing the ecological impacts of textile waste generation and management practices. This dimension examines:

- Waste stream composition and environmental persistence of different textile materials
- Life cycle environmental impacts of current versus proposed circular economy approaches
- Resource consumption patterns including water, energy, and raw materials
- Pollution patterns including air, water, and soil contamination from textile waste
- Ecosystem impacts and biodiversity implications
- Climate change contributions through greenhouse gas emissions
- Environmental benefits of circular economy interventions

Analysis employs material flow analysis principles where data permit, supplemented by qualitative assessment of environmental trade-offs and co-benefits.

Socio-Economic Dimension Analysis

Socio-economic analysis addresses the human and economic dimensions of textile waste management and circular economy transition:

- Employment patterns in textile production, waste management, and circular economy sectors
- Economic costs and benefits of different waste management approaches
- Market dynamics including formal and informal waste management sectors
- Social equity implications including gender, income, and geographic disparities
- Community health impacts from textile waste exposure
- Skills requirements and capacity building needs for circular economy transition
- Consumer behavior patterns affecting waste generation and management
- Cultural factors influencing acceptance of circular economy practices

This analysis incorporates both quantitative economic indicators where available and qualitative assessment of social dynamics and distributional effects.

Policy Dimension Analysis

Policy analysis examines the institutional and regulatory factors that enable or constrain effective textile waste management and circular economy implementation:

- Existing policy frameworks at federal, state, and local levels
- Regulatory gaps and inconsistencies affecting textile waste management

- Policy implementation challenges and enforcement mechanisms
- Stakeholder coordination and institutional arrangements
- Financial incentives and disincentives embedded in current policy frameworks
- International agreements and commitments affecting domestic policy
- Policy learning opportunities from other contexts and sectors
- Recommendations for policy reform and institutional strengthening

Integration and Synthesis Approach

The three analytical dimensions are integrated through cross-cutting analysis that examines interactions and trade-offs between environmental, socio-economic, and policy factors. This integration employs stakeholder analysis, system thinking approaches, and policy coherence assessment to identify leverage points for effective intervention.

3.6 Limitations of the Meta-Analysis

This meta-analysis has a number of methodological and contextual limitations that cannot be ignored when interpreting results and implementing recommendations.

Data Availability and Quality Limitations

The major limitation is related to the scarcity of good quality and similar data on textile waste management in Nigeria. Although recent systematic reviews have found a large amount of literature on global textile waste management, studies examining 243 research papers reduced to 104 to conduct an in-depth analysis, research in Nigeria is comparatively limited. This drawback requires the use of proxy information on similar settings and extrapolation of small case studies.

The diversity of the evidence available poses a problem to the quantitative synthesis. Different studies have different methodologies, concentrate on various issues related to textile waste management and in most cases, they do not have standardized metrics thus no direct comparison can be made. This restriction is mitigated by narrative synthesis methods, yet diminishes the accuracy of quantitative inferences.

Geographic and Temporal Limitations

The geographic sampling to Kaduna and Edo states, though motivated by their unique textile industry profiles, restricts the extrapolation of the results to other states in Nigeria with unique industrial backgrounds and settings. The study recognizes this weakness by stating factors that influence transferability of lessons learned.

The temporal constraints are due to the historical orientation of the experience of the textile industry in Kaduna, most of which happened some decades ago. Modern applicability of the historical lessons can be restricted by the alteration of technology, market situation, and regulations. This weakness is resolved by paying close consideration to contextual aspects to influence transferability over time.

Methodological and Publication Limitations

There is a risk of language constraints whereby research published in local languages of Nigeria or West African French might not be included. Although an attempt is being made to incorporate multi-lingual sources, some pertinent evidence can be overlooked.

The evidence base can be influenced by publication bias; successful circular economy projects can be reported more often than unsuccessful projects. This weakness is somewhat overcome by the inclusion of grey literature and industry reports, although it could still lead to an overestimation of the success rates of circular economy intervention.

The heavy use of secondary sources in most of the analysis prevents the possibility of checking the quality of primary data and can be biased in the interpretation of other authors. The limitation is overcome by triangulation through as many sources as possible.

Contextual and Implementation Limitations

The study is policy-oriented in terms of recommendations; it cannot consider all the challenges that can be encountered during implementation in practice. Applicability of recommendations may be influenced by political economy factors, dynamics of the informal sector, and the speed at which technology or market conditions change.

The literature search and analysis is constrained by resource limitations. Although systematic methods are used, not all possible sources that may be of interest are covered, especially in case of grey literature and unpublished studies.

Addressing Limitations in Interpretation

These constraints are handled in a number of ways: clear reporting of methodology and sources, cautious qualification of findings on the basis of the quality of evidence and its availability, clear discussion of uncertainty and gaps in understanding, as well as recommendations to conduct primary research to close identified gaps. The study focuses on identifying patterns and trends and does not require a specific approach to quantitative predictions and offers implementation research and monitoring elements to fill knowledge gaps.

CHAPTER 4. SYNTHESIS OF GLOBAL LITERATURE ON TEXTILE WASTE

4.1 Environmental Impacts

Landfill Contamination and Greenhouse Gas Emissions

Modern studies indicate that one of the most significant environmental issues in waste management systems around the world is textile waste. The rest of the textiles are burned or disposed of in landfills that increase carbon emissions, microplastic pollution, and chemical pollution such as PFAS, as per the

recent U.S. government analysis. The process of textile waste decomposition in landfills is a serious environmental hazard since during decomposition, the textile waste produces a large amount of greenhouse methane gas and pollutes the groundwater and soil with toxic chemicals and dyes.

The scope of personal contribution to this environmental burden is high. It has been found out that on average, the American produces approximately 80 pounds of textile waste every year and European consumption trends reveal that, in 2020, the average European consumed 14.8kg of textiles. This pattern of consumption multiplied by the world populations places unprecedented pressure on the waste management systems and environmental resources.

Environmental effects of the textile waste are exacerbated by the fact that the waste contains synthetic materials. Landfill wastes such as textiles that contain per- and polyfluoroalkyl substances (PFAS) are capable of releasing gases containing these contaminants to cause long-term environmental pollution that would continue to contaminate the ecosystem decades after introduction. These tenacious chemicals present a particular challenge to developing nations that have poor waste management facilities.

Water Pollution and Chemical Contamination

The impact of the textile industry on water pollution around the world goes way beyond the manufacturing stage to include considerable effects of waste disposal and waste management. Recent studies determine that 20% of the total wastewater is produced by the fashion industry and the volume of greenhouse emission is expected to rise to 50% in 2030. This enormous contribution to water contamination embodies both the production activities as well as the downstream consequences of disposing textile waste.

Textile waste disposed of in landfills poses especially serious problems of water contamination. The dumping of textile waste in land fills can also increase water pollution and as the degradation of textiles causes toxic chemicals and colors to spread to the soil and groundwater, they can contaminate nearby water bodies and pose risks to human health and aquatic organisms. This route of contamination is of particular concern in the areas with ground water as the major source of drinking water.

Modern textiles are more complex in chemicals, which increases the effects of water pollution. Textile waste has a variety of chemical treatments, dyes, and finishes that may leach to a water system over a long period. Such chemicals usually include heavy metals, azo dyes, formaldehyde-based agents and other chemicals that continue to linger in water systems and accumulate in the food chains.

Microfiber Pollution and Marine Ecosystem Impacts

Microfiber pollution is not only confined to aquatic environments in immediate surroundings. The synthetic textile sheds microfibers into the water during the washing process, which pollute water bodies and are a source of contamination of the ocean due to microplastic, posing significant effects on aquatic life and ecosystems. This route of contamination causes the development of long term environmental problems which are hard to cure and still persist in the ecosystems even after the initial textile products are disposed of.

The worldwide prevalence of microfiber pollution indicates the supremacy of artificial fabrics in modern textile manufacturing. Since the percentage of global textile manufacturing is taken up by synthetic textiles, especially in the fast fashion industry, this means that the quantity of microfiber contamination is expanding exponentially. This has been a worrying pattern considering that there are only a few technological remedies that can be used to trap microfibers in the washing operation.

The latest studies show that microfiber pollution is not only having impacts on marine life but also on the ground by the way of irrigation using polluted water and deposition to the atmosphere. The scope of ecosystem effects is an active field of research, yet emerging evidence indicates that there are large-scale impacts on biodiversity, food web dynamics, and ecosystem functioning at multiple scales.

4.2 Public Health Implications of Textile Chemicals

PFAS Exposure and Health Risks

PFAS in textiles is an important and increasing public health issue, where the consequences are not limited to industrial employees, but to the ultimate consumer. It has been found out that polymeric PFAS compose more than 75 percent of PFAS in textile products and are employed to endow products with functionality, and both polymeric and non-polymeric PFAS are also emitted throughout the life of a product such as textile washing.

The health effects of the exposure of PFAS via textile are harsh and well-established. It has been found out that exposure to PFAS leads to endocrine disruption, immunosuppression, high cholesterol, reproductive damage, and many types of cancers, and these chemicals accumulate over time to the point that even minimal exposure can be detrimental. PFAS compounds are bioaccumulative in their nature and therefore even minimal exposure to them can lead to serious health effects in the long run.

The worst route of exposure to PFAS is occupational exposure. Studies by Norwegian NGO Future in Our Hands assert that factory workers in China, who manufacture textiles to serve western markets, are being subjected to a disastrous effect on health due to high levels of exposure to PFAS chemicals. This is an occupational route of exposure, which points to the health inequities in the textile production systems worldwide, where workers in the developing world suffer disproportionately.

PFAS gets into the consumer via textile products in a variety of ways. Recent reports identify some traces of the poisonous “forever chemicals” referred to as PFAS in consumer textiles such as bedding, tablecloths and sportswear items. The consumer exposure route implies that the exposure to textile-related PFAS has an influence on the population much more distant than industrial workers and the population surrounding the production facilities.

Occupational Health Impacts in Textile Production

The health risks of the workers working in the global textile supply network are serious due to the exposure to textile chemicals at the workplace. PFAS have been suspected of causing cancer and other

health effects on workplace workers and chemical manufacturing workers have been more exposed to PFAS compared to the general populace. The pattern of this occupational exposure shows that health hazards are concentrated on the industrial employees who are involved in the production processes involving these chemicals.

The occupational exposure pathways are manifold and are not properly managed. During textile and leather production, volatile PFAs may be emitted to indoor air and outdoor air, and this is one of the routes of textile and leather worker exposure and deposition onto soil and surface water. Such numerous exposure pathways imply that the health risk is complex on the part of workers and cannot be sufficiently addressed using the conventional occupational safety and health measures, which consider individual exposure pathways.

The textile manufacturing factories contaminate the environment extending the health effects to the immediate workers to the nearby communities. PFAS can be introduced by leaks and spills in textile facilities into soil and groundwater, which provide routes by which the community might be exposed to through contaminated drinking water sources and agricultural products.

Textile manufacturing is a globally located industry and therefore the occupational health effects are usually concentrated in the third world countries where there are less strict occupational health policies. This geographic clustering of health hazards mirrors larger trends in environmental and health disparity in the global supply chains where production gains are received in the developed world, and the health costs incurred in the developing world are suffered by workers and the surrounding communities.

Community Health Impacts and Environmental Justice

Waste disposal and textile production have considerable health effects on the communities around the facilities of waste disposal and production. These effects are indicative of larger trends of environmental injustice in which the less powerful groups in society have unequal environmental health access to industrial processes, which mostly accrue to the more financially secure groups.

Exposure of the community to chemicals used in textile is through various routes such as air pollution, contamination of water and soil pollution. The fact that chemicals such as PFAS have a persistence effect implies that community health effects may last long after the production activities have been closed down or outsourced. This is a time aspect of chemical exposure that leaves long term health legacies of the community residents across several generations.

Cumulative exposure to textile chemicals in the community adds health risks to a large extent. The communities around the textile manufacturing plants tend to be exposed to a variety of chemical hazards at the same time that form synergistic health effects which can be worse than the health effects of exposure to the individual chemicals. Such a tendency of cumulative exposure is especially alarming considering the little knowledge of interaction effects between various textile chemicals.

Environmental justice is of special concern to the health effects of textiles since the production plants and the garbage dumping locations are frequently placed in low-income neighborhoods and communities of

color. Such communities often lack political influence to oppose decisions on facilities location and do not have access to health care resources that would help them mitigate the adverse effects of chemicals on their health.

4.3 Circular Economy Models in Fashion: Global Best Practices

European Union Leadership in Circular Textile Policy

The EU has become the forefront in formulating holistic policy in the implementation of the circular economy in the textile industry. The EU Strategy of Circular and Sustainable Textiles of 2022 is the foundation of the whole chain of policies concerned with the transition between fast fashion and circular fashion. This strategic framework is the most ambitious effort to achieve systematic change in textile production and consumption patterns by intervention policies.

In the EU solution, the concept of extended producer responsibility is a fundamental approach to a circular economy transition. Its strategy is to establish a greener, more sustainable, and innovative textile industry with longer producer responsibility, longer periods of consumer access to high-quality, low-cost textiles, and re-use and repair services to be profitable economically. This strategy redirects economic incentives along the value chain towards durability, repairability and recovery of end of life.

The textile waste management has mandatory infrastructure development as part of the application of the principles of the circular economy in the EU. All EU Member States will need to have systems in place by January 1, 2025 to separate the collection of textile waste, i.e. textiles must undergo separate collection with other waste streams. This infrastructural need provides the platform upon which the textile materials can be systematically recovered and worked on at a large scale.

Transparency and accountability in environmental claims are other aspects that the EU approach focuses on. In 2024, MEPs passed a law that prohibited generic environmental claims made on products in the absence of evidence, which is a rampant issue of so-called greenwashing that disrupts consumer trust in sustainable textiles products. This control model also contributes to the wise decision-making of consumers and motivates real sustainability gains.

Design for Circularity and Eco-Design Principles

Modern theoretical frameworks of the circular economy in fashion focus on design-level interventions that allow circular product lifecycle material flows. Fashion businesses can also adhere to laws through sustainable practices and due diligence, by using sustainable materials and Ecodesign to address the requirement of the circular economy and the environment. This design-based strategy acknowledges that the products in the circular economy should be designed to ensure that the outcomes are incorporated in the products and not added-on at the end of life.

Eco-design in the textile industry is based on the choice of materials, durability, repair, and recovery in the end-of-life. These values demand radical reshaping of design processes where aesthetics-driven design thinking has given way to those approaches that span product lifecycles and rely on systems thinking. To

apply eco-design principles, it is usually necessary to make major adjustments to how designers are trained, the material sourcing processes, and production methods.

The combination of the application of circular design and the demands of consumers poses a constant problem of fashion brands. Circular design usually involves trade-offs among aesthetic diversity, affordability, and environmental performance which can not be consistent with traditional models of the fashion business. To make the process of implementing a cycle a success, it will need both technical and business model innovations to render it economically viable.

In facilitating circular design methods, material innovation is essential. Circular fashion systems need to include development of bio-based materials, advancement of recycling technologies, and design approaches that can be used to recover materials. Such innovations entail a lot of research and development investment and alignment among various industry stakeholders.

Digital Technologies and Supply Chain Transparency

Digital technologies are becoming widely accepted as the drivers of the implementation of the circular economy in textile supply chains. Transparency, accountability, and optimization Circular material flows are sustained with the help of digital product passports, blockchain-based traceability systems, and artificial intelligence applications. These technological solutions deal with information asymmetries that have been a limiting factor of the development of the circular economy in the past.

Digital technologies provide supply chain transparency that allows checking the sustainability claims and makes consumers make a well-informed decision. Immutable material provenance, production processes and environmental impacts records can be availed by blockchain and other distributed ledger technologies. These systems of transparency will be crucial in creating confidence in products of circular fashion and justifying higher prices of sustainable alternatives.

New business models that are founded on sharing, renting, and provision of services as opposed to owning products can also be achieved through digital platforms. The platform-based business model is capable of greatly cutting down the material throughput, with no harm or even an increase in the consumer access to fashion goods. The success of these models is determined by technology infrastructure, acceptance by the consumer and regulation.

The use of machine learning and artificial intelligence in textile manufacturing and waste treatment presents the possibility of optimizing the flow of materials in a circle. Such technologies are capable of enhancing demand forecasting, streamlining the production process, quality control and sorting of waste textiles into recycling in an automated manner. This involves a lot of technology investment and development of the workforce during implementation.

Global South Innovations and Community-Based Models

The innovations of the Global South are more inclined towards circular economy and community-based strategies along with informal sector inclusion compared to models of technology-oriented circular

economy in the developed world. These solutions often extend into already developed informal waste management systems and more traditional textile practices that have cyclical ideals.

Recycling and upcycling of textiles on a community level in developing countries has shown that locally-adapted models of the circular economy can exist. Such initiatives usually have both the economic development aim and the environmental goals, where marginalized communities get income opportunities whilst the issue of textile waste is solved. The community ownership, proper choice of technology and market development of recovered products are considered to be the success factors.

Incorporation of the informal sector workers in the formal circles of the economy comes with opportunities, as well as challenges. Informal workers usually have specialized knowledge and skills in textile recovery and processing, and they might not have access to technology, capital, and markets that can facilitate the expansion of their operations. The achievement of the inclusive development of a circular economy is impossible without policy frameworks that acknowledge and encourage the role of the informal sector.

The conventional textile processes practiced in most developing nations reflect the principles of circle that can be applied to the present-day models of circular economy. These social practices involve the use of natural dyeing, cultivation and processing of fibers as well as repair and reuse customs that ensure optimal use of materials. The development of culturally-appropriate and technically-effective approaches to the circular economy can be supported by learning based on traditional practices.

4.4 Policy and Governance Responses Worldwide

Regulatory Frameworks and Extended Producer Responsibility

Extended Producer Responsibility (EPR) is a strong policy instrument that has appeared and taken the forefront in dealing with the waste of textiles and advancing the idea of the circular economy worldwide. EPR programs transfer responsibility of end of life management to producers and municipalities as opposed to consumers and this provides the economic incentives to enhance the product design and end of life recovery mechanisms. The implementation differs in many ways between jurisdictions depending on different regulatory practices and market conditions.

The strategy of textile EPR by the EU is the most elaborate framework that is currently being developed. This regulatory framework is a mixture of compulsory separate collection and producer responsibility to fund waste management systems. This strategy establishes direct economic connections between production choices and end-of-life expenses to motivate manufacturers to help in product design and material selection decisions to take full lifecycle effects into account.

The problems encountered during the EPR implementation in developing countries are quite high since informal sectors have dominant roles and formal waste management systems are scarce. The EPR structures in such settings need to focus on informal sector assimilation, capacity building, and institutional growth. The ability to adjust the principles of EPR to the local circumstances instead of bringing to the country models that have proven successful in other settings is the key to success.

Institutional capacity and enforcement mechanisms are very important to the effectiveness of EPR systems. Poor regulatory implementation can compromise effectiveness of EPR enabling free-riding behavior in which some of the producers can escape responsibility whereas others incur disproportionate costs. Effective enforcement needs to be invested in institutions of regulation, systems of monitoring, and penalty systems.

International Cooperation and Trade Policy Integration

The need to manage textile waste internationally is becoming more and more clear due to the international character of textile supply chains and the international flow of textile waste. Existing waste management frameworks used internationally, such as the Basel Convention, do not cover the waste streams in textiles and the principles of the circular economy. Generalization of international frameworks or creation of more comprehensive ones involves the coordination of various stakeholders that have different interests and abilities.

The integration of trade policy and focusing its objectives on a circular economy have both opportunities and challenges to textile waste management. The EU Strategy on Sustainable and Circular Textiles seems to be very ambitious, yet the fact that it does not sufficiently address the issues of key partners in the trade making it hard to adjust to the ambitious strategies of the strategy poses a threat to the success of this strategy. This challenge underscores the necessity of involving approaches that can help in developing capabilities in trading partner countries.

Capacity building programs and international technical assistance are important in the facilitation of global circular economy transition. These initiatives can assist developing nations to develop institutional capacity and to design suitable technologies as well as establish policy frameworks that facilitate the development of the circular economy and also meet the local development priorities. Good programs have to be long-term and adjusted to the local conditions.

The adoption of the principles of the circular economy in the global trade agreements provides the possibilities of the global expansion of the circular economy strategies. The provisions of trade agreement may promote technology transfer, trade of recycled materials, and development of incentives that will encourage sustainable production. Nevertheless, this kind of integration must be done with due consideration of the effects of development and the capacity of countries involved.

National Policy Innovation and Adaptation

The national policy responses to the challenges associated with textile waste differ greatly in the scope, approach, and the implementation mechanisms. The major economies have come up with broad approaches that incorporate various policy tools whereas others are narrow in their approach either waste management or producer responsibility. Such divergence is a manifestation of varying political priorities, institutional possibilities and economic states.

France has been the first to implement a number of novel policy solutions such as compulsory waste minimization rates, textile destruction, and promotion of repair and reuse services. Such policies form a holistic framework that tackles various textile value chain considerations as well as facilitating the formulation of circular business models. Difficulties in implementation are coordination of enforcing the law by several agencies and balancing the effects on the economy on the industry.

The United States has been more fragmented where the state-level initiatives have been in the forefront of developing the federal policy. The report by the U.S government suggests that the Congress should assign a federal institution to lead in making efforts to minimize textile waste and promote recycling. This recommendation is based on the acknowledgment of the necessity of more coordinated national solutions to the textile waste management.

Circular economy policy adaptation to local circumstances is of specific concern to developing countries. There is low institutional capacity, competing development goals and resource constraints that influence policy development and implementation. To adapt successfully, one needs to pay attention to local circumstances, stakeholder involvement, and a step-by-step process that allows building capacity and solving urgent problems.

Multi-Stakeholder Governance and Partnership Models

The emerging need of good textile waste governance is the multi-stakeholder strategies that would bring different players into value chains and policy relations. Such alliances have the ability to exploit various stakeholder competencies and resources as well as establish a consensus on mutual goals. This requires well defined governance systems, coordinated incentives and superior coordination systems to be successful.

Public-private collaborations are significant in the provision of circular economy programs, especially in the development of infrastructure and the use of technologies. These alliances are able to bring together governmental regulatory powers and funding with business expertise and cost effectiveness. Partnerships must be effective in terms of role definition, arrangements of sharing risks and accountability.

Self-regulation and voluntary standards in industries are important in achieving the development of the circular economy but have limitations in terms of coverage, ambition and enforcement. Regulatory development that is facilitated by industry initiatives can be motivated and enhanced by innovation, but it usually needs regulatory frameworks that are supportive in ensuring coverage and avoiding free-riding behavior.

The civil society organizations are significant in the advocacy, monitoring, and implementation of the circular economy initiatives. These organizations have the ability to independently verify the claims made by the industry, push for stricter policies, and enhance the implementation on a community basis. Proper engagement will mean that it has to be well-funded, technical, and reach to the decision making processes.

CHAPTER 5. NIGERIA IN FOCUS

5.1 National Overview of Textile/Fashion Waste Challenges

The problems of the textile and fashion waste in Nigeria can be considered as the multifaceted combination of the historical fall of industries, the blistering urbanization and changing trends in consumption. The waste management system used in the country in textile waste management is in a larger context on a poor waste management infrastructure and poor regulation frameworks that are unable to deal with the increased amounts of textile waste produced in urban centers.

The magnitude of the textile waste problem in Nigeria is further enhanced by the fact that the textile sector in Nigeria has undergone a tremendous change in the last thirty years. By the 1990s, the textile industries in Kano, Kaduna and Lagos were forced to shut down, thereby textile materials were mostly imported in countries such as China, Germany, India, United Kingdom, etc. This change in the local production to the importation has completely changed the fiber of textile waste in Nigeria and this change has implications to both disposal methods and the environment in Nigeria.

In Nigeria, modern textile waste includes both post-industrial and post-consumer wastes, but the proportion of the relative waste has changed under the impact of the degradation of the domestic production. There is also the post-consumer waste which is mostly as a result of more consumption of imported garments and textile especially in the Asian markets. This market of imports poses certain hurdles to the waste management process because much of the imported textile products are made of synthetic fabrics and chemical processes that are not biodegradable and can therefore not be easily handled through the conventional methods of waste disposal.

The informal sector is important in the contemporary textile waste management environment in Nigeria, whereby there are systems of collectors, sorters and recyclers who operate in the major cities. These informal systems show that there is a possibility of circular economy approaches and that it is difficult to incorporate informal practices in the formal waste management systems. Studies have shown that there has evolved informal recycling and trading networks of textiles that have established advanced material recovery and redistribution procedures, though with little additional technological aid and regulation.

The textile waste composition and management in the region is different because Nigeria was a multidimensional economic and cultural environment. The northern states with the historical experience of textile production such as Kano and Kaduna are challenged differently with the southern commercial centers such as Lagos where importation-based consumption is the driving force behind consumption patterns of waste. These local peculiarities demand specific solutions to the waste management problem that take into account the economic activity of the region, local culture, and the potential of local institutions.

5.2 Review of Academic and Policy Literature

Scholarly sources on textile waste management in Nigeria are relatively scarce relative to the environmental and waste management literature as a whole, a factor that can be attributed to not only the

relative novelty of textile waste as a policy problem, but also to the inherent difficulties of empirical research in the area. Nevertheless, the literature review offers important information on how the industrial policy, environmental management, and economic development are interrelated in the textile industry of Nigeria.

Recent studies examine issues in the Nigerian textile industry and also analyse the success of economic recovery measures on the sector using survey methodology, which gathers primary data using structured questionnaires sent to 200 respondents. This method of research indicates the increased acceptance of the fact that the problems of the textile industry involve both economic and environmental aspects that should be analyzed together.

The scholarly sources demonstrate that there are critical lapses in the knowledge about the environmental effects of textile waste in Nigeria. The textile business in Nigeria is perceived to have dubious sources of stimuli, political instability, severe deficiency of power, inadequate infrastructures and smuggling, yet the scientific study on the environmental impact of these institutional setbacks is underdeveloped. This introduces a gap in the evidence on policy interventions related to textile waste management and development of the circular economy.

The literature of policy in relation to textile waste management in Nigeria is also quite thin and most policy analyses are concerned with industrial development as opposed to waste management. Research analyzes the changes and dynamics, as seen in the historical achievements and setbacks of the Kano textile industry, viewing the phenomenal tendencies in the textile trade and production in Kano and discussing the debilitating character of the textile activity. These historical reflections offer valuable background of comprehending existing issues yet tend to omit express consideration of environmental and waste management aspects.

The paucity of academic sources on textile waste in Nigeria is unlike the increasing literature availability on management of textile waste in developed nations as well as other emerging economies. This gap can be attributed to resource limitation of Nigerian research institutions as well as the comparatively new status of the textile waste as a serious environmental problem that should be systematically studied.

Recent scholarly literature has started to fill some of these gaps using interdisciplinary methods building bridges between the studies of industrial policy and environmental assessment. The research findings reveal that the textile industries in Nigeria are losing their business performance due to low patronage by the consumers who are not satisfied with the quality of the products offered to them and the industries are faced with limitations and difficulties. The methodology of research proves the possibility of complex study of the issue that puts into account both economical and environmental aspects of performance of the textile industry.

The introduction of the feasibility studies of the textile waste recycling is a positive change in the literature realm. The textile waste recycling in Nigeria now has expert feasibility studies within consulting services that can be used to unlock potential solutions and success stories that can transform the industry. These applied research projects imply a developing commercial and policy concern in creating viable options in dealing with textile waste.

5.3 Stakeholder and Institutional Landscape

The stakeholder and institutional environment of textile waste management can be described as fragmented on multiple levels of government, there is a lack of coordination among actors operating in both formal and informal sectors and the role of the private sector and civil society organizations is changing. The significance of knowing this landscape is that it will help come up with effective policy interventions that will be able to capitalize on the available capacities and overcome institutional gaps.

Government agencies that participate in the management of textile wastes have overlapping and conflicting roles at federal, state, and local levels. The federal agencies such as the Federal Ministry of Environment and National Environmental Standards and Regulation Enforcement Agency (NESREA) offer the general policy frameworks and national environmental standards, and the state agencies of environmental protection undertake the implementation and enforcement at state level. Local government authorities are in charge of collecting and disposing of their waste material but in most cases they lack the technical and financial capacity to deal with the textile waste effectively.

The environmental management aspect of the industrial policy is the institutional frameworks that cut across environmental management through the Federal Ministry of Industry, Trade and Investment and the Industrial Development Bank of Nigeria. Nevertheless, there is limited coordination between the institutions of industrial development and environmental management agencies that result in gaps in managing waste implications of the textile industry policies and programs.

The roles of state-level institutions are especially significant because the activities of the textile industry are geographically concentrated, and the responsibilities on the environmental management are distributed to the state governments according to the constitution. Other states such as Kaduna and Kano, which have had a long-standing history of textile industry, have also come up with specialized institutions and programs that deal with industrial revitalization though this has historically been based on the production-related elements of waste management.

The informal sector is a very vital yet little known part of the textile waste management in Nigeria. Informal waste collectors, sorters, recyclers and traders have large networks where they take processed volumes of textile waste especially in urban regions. These informal systems can be innovative in their material recovery and reuse practices, yet are unsupported by an institution or regulated according to current laws.

The stakeholders in the management of wastes in the textile industry that are operating in the private sector are the formal waste management companies as well as specialized textile recycling businesses. The traditional scope of the formal waste management sector in Nigeria has been on the municipal solid waste collection and disposal, but the specialized waste streams such as the textile waste have not been given much consideration. Nevertheless, increased publicity about the opportunities of a cyclical economy is starting to draw investment in the processing and recycling technologies in the textile waste by the private sector.

The international development agencies and donors are significant stakeholders who sponsor the development of the textile industry as well as environmental management in Nigeria. Different efforts concerning industrial development, environmental management and circular economy development have been encouraged by organizations like the World Bank, African Development Bank, as well as bilateral development agencies, but textile-specific programming is scarce.

Academic and research institutions play a role in the stakeholder environment by conducting research, capacity building and policy analysis programs. Technological colleges that have engineering, environmental science, and textile courses have significant roles in generating technical solutions and preparing human resource in the textile and waste management industries. Nevertheless, the research capacity is still low and the connection between the academic institutions and policy-making processes needs to be reinforced.

The civil society organizations that specialize in environmental protection, waste management and sustainable development have also started to tackle the issue of the textile waste as an aspect of wider advocacy and program action. These groups usually have important roles in creating awareness, policy reforms and helping communities to manage the waste produced locally.

CHAPTER 6. COMPARATIVE CASE ANALYSIS - KADUNA TEXTILE INDUSTRY

6.1 Historical Role and Decline of Kaduna Mills

The textile industry of Kaduna is an interesting historical case study on the potential and problems of industrial development in Nigeria, and its significance to the modern textile waste management and circular economy efforts. In 1955, officials of the northern Nigerian government in collaboration with the British textile company David Whitehead & Sons, made successful efforts to initiate plans to construct the first large scale textile manufacturing plant in the region. This institution was the start of what was to emerge as the biggest textile production area in the whole of Nigeria.

The textile industry of Kaduna was an act of industrial policy intervention whose aim was to substitute imports and economic diversification. The decision to select Kaduna as the site was based on strategic factors such as distance to cotton growing areas, water resources, transport system, and governmental encouragement. The successful experience of the Kaduna Textiles Limited (KTL) plant showed that high-scale textile production was possible in Nigeria and invited more investors into the industry.

The textile industry in Kaduna in the 1960s to 1980s was a booming industry that made major contributions towards the prosperity of the region. The growth in the industry during this era involved various factories that manufactured a great variety of textile products, both in their raw material form (fabrics) and their finished product (garments). The development of the sector facilitated massive employment opportunities not only in the manufacturing process but also in the supply chain integration and local multiplier effect of the economy.

The combination of the textile sector in Kaduna and the local and foreign markets at the time of its boom created the preconditions of significant material flows and waste production. A large-scale production of

textile inevitably produced large quantities of production waste, such as fiber waste, fabric off-cuts, defective goods, and water and sludge contaminated with chemical products. The way these waste streams were handled at the peak time of the industry created some patterns and practices that are still used in the current waste management practices.

Nonetheless, the industry went through a steep drop as a result of old machinery, inefficient supply chain management and economic issues. This was not a one week event but a gradual process that took place during a number of decades where various facilities were closed or had their operations reduced at various points. The progressive character of the decrease implied that the systems of waste management and environmental effects developed during a long period of time.

The shutting down and the abandonment of textile plants left tremendous environmental footprints that have impacted on modern waste management initiatives. The textile processing machines, chemical storage plants, and waste dumping are some of the sources of environmental inconveniences that have to be removed and handled. The relevance of long-term environmental impacts in industrial policy and planning processes is shown by these legacy issues.

6.2 Key Findings from Existing Studies

Scholarly studies on the textile industry in Kaduna have produced valuable information on the determinants of industrial success and failure, and have implications on how waste management issues and opportunities of the circular economy can be addressed. Studies have cited poor power supply, lack of consistency in government policies, smuggling of foreign made textiles, and insecurity as the major factors that are affecting the Nigerian textile industry and the efforts of reviving the industry with the intervention of fiscal and monetary policies appear to bear no fruits.

The contribution of infrastructure constraints to the decline in industries is specifically applicable to the waste management systems. The issue of power supply which influenced the production of the texts also affected the waste treatment and disposal systems and therefore restricted the scope of the environmental management practices. Study shows that the lack of infrastructure has cascading impacts on both the production efficiency and environmental performance, a factor that underscores the interrelationship between industrial and environmental issues.

Waste management and the development of the circular economy are greatly affected by policy inconsistencies observed in the literature. In 2007, UNTL mill in Kaduna was closed, but later in December 2010, it was reopened with the help of the Cotton, Textile and Garment Development Fund of 100 billion nairas. Such chain fading and re-emerging pose uncertainty in long-term waste management system and circular economy investment planning.

The effects of trade policy on the textile industry provide valuable insights into waste management strategy. The studies have shown that import competition influenced the production of domestic textiles to the extent of radically transforming the textile waste compositions in Nigeria. The replacement of domestically-generated textile waste (with known material compositions and processing histories) with

imported textile waste (with varying and often unknown material properties) poses new challenges to waste management and recycling systems.

The anthropological study has given rare information on the social and cultural aspects of the fall of the textile industry. The study is based on the reflections of the work of the dead, in the event of deindustrialization, i.e., the deterioration of the textile industry in Kaduna, and its impacts to the families of the deceased workers, revealing how the dead labor in different forms to Christians and Muslims who were employed in KTL mill. This study illustrates the strong social entrenchment of the textile industry processes and the long-term societal effects of industrial degradation.

The global aspects of textile industry development at Kaduna demonstrate valuable lessons concerning technology transfer and industrial cooperation. The study of Chinese- Nigerian cooperation in textile industry indicates opportunities and challenges relating to international cooperation in industrial development. These experiences can shed light on modern work on the creation of technologies and systems of the circular economy based on international collaboration.

Policy intervention studies in the textile sector of Kaduna show trends applicable to the modern policy development of a circular economy. The partial failure of other revival initiatives implies the use of holistic measures that consider many aspects of industrial competitiveness such as environmental sustainability and waste management. Such policy interventions that concentrate on the production but do not look at the waste management and environmental effects can be unsustainable in the long run.

6.3 Environmental and Socio-Economic Outcomes

The environmental performance of the textile industry Kaduna trajectory includes the effects of the industrial activity at the height of the sector and the current environmental effects of the decline and abandonment of the industries. Textile production in Kaduna created a lot of environmental effects during the peak production period such as water pollution through the dyeing and finishing processes, air pollution through energy production and chemical processing and solid waste through the production processes and faulty products.

One of the most important environmental effects of textile manufacturing in Kaduna was water pollution. The processes of textile dyeing and finishing consume a lot of water and produce wastewater that contains dyes, chemicals, and suspended solids. The emission of poorly treated textile wastewater produced short-term and long-term effects on the local water bodies and the ecological system and human health of the local communities.

The disposal of solid waste generated during textile production had environmental issues that continued even after discontinued production. Wastes in textile production were fiber waste, fabric off-cuts, defective products, packaging materials, and chemical containers. Disposal of these wastes in the local landfills or informal dumpsites posed a continuous source of environmental pollution, especially considering the existence of synthetic materials and chemical residues which do not easily biodegrade.

The socio-economic experiences of the development and decline of the textile industry in Kaduna have provided useful insights into the overall implications of industrial policy on the welfare and development of communities. The textile industry was at its best, offering a huge number of job opportunities both directly in the production process and indirectly in the supply chain connections and in the local economic multiplier impact. The industry was a significant employer in the region and therefore its decline had dire impacts on the localities and the economic growth of the region.

This downturn of the textile industries in Kaduna generated a lot of social and economic unrest that went way beyond the direct loss of jobs in manufacturing. Shutting down of textile plants impacted whole communities that had grown around the industry, and retail stores, service providers and transport systems that relied on the textile sector to be economically active. The economic disruption that has a long-term character demonstrates the relevance of community resilience and transition planning in industrial policy.

Gender aspects of textile industry degradation in Kaduna provide significant information regarding the disparate effects of industrial transformation. Women were also very much represented in textile manufacturing jobs in the formal factory jobs and also in informal sector jobs involving the textile processing and trading. The de-industrialization of formal textile production had a disproportionately negative impact on women in terms of work opportunities and economic stability, and household well-being and community growth.

The development and decline of the textile industry in Kaduna has environmental justice implications that are broader than industrial development trends of environmental inequalities. The effects of textile manufacturing on the environment, such as water pollution and solid waste discarding, were disproportionately experienced by low-income communities living close to the factory. These communities tended to be quite weak in terms of political strength and economic capability to impact the decision on where industries should be located or insist on proper protection of the environment.

6.4 Lessons from Policy Interventions in Kaduna

The policy interventions implemented to help revitalize the textile industry in Kaduna offer valuable insights to modern efforts to create a circular economy model of textile waste management. The history of policy interventions demonstrate the possibility of government intervention to facilitate industrial development as well as the constraints of the policy interventions which are limited to a specific issue without resolving systemic issues.

The initial policy interventions, which were aimed at industrial development and import substitution, managed to develop the textile manufacture capacity in Kaduna, proving that strategic government intervention could be used to generate new industrial sectors. The collaboration between government organization and foreign company in the development of the first textile plants demonstrated the importance of the integration of the strategic planning of the government and the technical skills and investment capital of the business world.

Nevertheless, these early achievements were hampered by policy incoherence and inability to meet changing competitive pressures in the long-term. The collapse of the textile industry followed numerous

attempts of revival, which can be interpreted as the indication that successful industrial policy needs to be committed to and adjusted to the alterations in the economic environment. The partial failure of revival actions underscores the need to have multi-dimensional strategies that would accommodate various aspects of industrial competitiveness.

The issue of infrastructure policy turns out to be a vital determinant of the level of industrial competitiveness, as well as the environmental performance. The failure to provide reliable electricity supply impacted on the efficiency of production and on the functioning of waste treatment systems, which testifies to the interdependence of the infrastructure problems. The successful construction of the circular economy must be based on coordinated investments in the infrastructure that facilitates the development of the production process and the environmental management system.

The interventions of trade policies provide some valuable lessons to the necessity to balance the protection of local industries against environmental concerns. Restrictions on imports to support domestic textile manufacturing might have unintended impacts on waste management when they influence the construction and properties of textile products offered in domestic markets. The production and consumption patterns must be taken into account in the design of policies in a circular economy.

The practice of providing international development aid and textile industry revival loans can offer lessons applicable to funding the circular economy programs. The 100 billion naira Cotton, Textile and Garment Development Fund which helped UNTL mill to resume production in December 2010 illustrates both the possibilities of funding industrial development using public funds and the difficulties in ensuring long-term sustainability of activities supported by the fund.

The experience of regulatory policy in the textile industry in Kaduna highlights the need to integrate environmental management with industrial policy. The effects of the production of textiles on the environment in the era of the textile industry prosperity, and the current environmental heritage of the industrial recession, proves the necessity of the formation of a thorough system of regulations that reflect both the production and waste management condition of the activity of the textile industry.

The relative failure of sectoral policies based on the focus on textile manufacturing only indicates the effectiveness of combined strategies that would cover various aspects of sustainability, such as waste management and the development of the circular economy. Modern policy interventions aimed at textile waste management and the development of the circular economy can apply this lesson to guarantee a multifaceted approach that considers all three dimensions of production, consumption, and waste management.

It turns out that institutional capacity building is one of the key factors influencing the effectiveness of policy implementation. The experience of trying to execute a number of policies in the textile industry in Kaduna illustrates institutional capacity limitations that are prevalent in a number of areas of industrial and environmental policy in Nigeria. The development of effective circular economy policy needs to be sustained through institutional capacity building at various government levels and various sectors of interest.

CHAPTER 7. POLICY OPPORTUNITIES FOR EDO STATE

7.1 Review of Existing Policy Literature on Edo's Industry

Academic sources that specifically cover the state of Edo textile and fashion industry are scarce compared to the larger body of literature that covers the other Nigerian textile centers of interest, both in terms of the comparative recent development of Edo into a target of textile industry research and the tendency of current researchers to focus on historically important textile industries such as Kaduna and Kano. This state-specific literature gap presents both challenges and opportunities to the development of evidence-based policy in Edo State.

The research on the wider textile industry in Nigeria which is available gives an idea of the context in which Edo State fits in the national picture. According to research, textile firms in Nigeria lack value to quality designers, intellectual property right and originality of design which implies that there are systematic challenges which probably affect the new textile centers such as Edo State. The outcomes of the questionnaire and interview methods with the help of the descriptive statistical analysis point to the underlying structural problems in the textile industry in Nigeria that need to be addressed both on the national and state levels.

The paucity of state-specific literature on the textile industry in Edo can be viewed as representative of larger trends in the Nigerian industrial research literature, in which the scholarly focus has traditionally been on those industrial hubs that are already developed, and not on those that are developing, or those that could be developed. This gap in research presents the Edo State with the opportunities to use the lessons learned in other settings as well as come up with innovative solutions that would suit the local circumstances and specific current challenges.

Modern studies on the creative industries in Nigeria offer certain information that can be used in the future developmental path of Edo State. Research on the growing international popularity of the Nigerian fashion industry and how the industry has also improved the Nigerian soft power indicates that state-level fashion and textile policies can support the larger national development agenda. According to this research, the development of the textile and fashion industry in Edo State can be enhanced by being placed in the section of the emerging creative economy in Nigeria.

The lack of detailed scholarly literature on the textile industry in Edo State itself poses challenges and opportunities to the development of policies. Although this restricts the accessibility of state-specific empirical data to guide policy development, it also offers Edo State the chance to adopt new methods that would add to the general body of knowledge regarding textile industry development in Nigeria.

7.2 Waste Management Practices Documented in Secondary Sources

The literature on waste management practices within Edo State, specifically in relation to textile waste, has been very scanty in the scholarly literature, which is not only an indication of the underdevelopment of formal textile industry operations within the state but also the overall difficulty in documenting waste

management practices within the Nigerian context. Nevertheless, existing data on the waste management practices in other comparable situations in Nigeria will yield pertinent information to aid in comprehending the possible avenues and obstacles in handling textile waste in Edo State.

The national context of textile waste management in Nigeria shows that there are systematic issues that are likely to impact on Edo State and other states within Nigeria. It has been proven that textile waste represents a substantial proportion of municipal solid waste disposed of in the landfill or via incineration, and novel management approaches are crucial to improve sustainability and circularity. This national background infers that Edo State has comparable issues in handling textile waste streams, especially with the growing presence of imported textiles in Nigerian markets.

The existing waste management systems in Nigeria are typified by the lack of formal infrastructure and the high levels of informal sector operations. Although no particular record exists of these practices in Edo State, more general studies of waste management systems in Nigeria indicate that textile waste management in Edo probably adheres to the same patterns, with informal systems of textile waste collection and processing managing large amounts of textile waste alongside other waste.

The shift in Nigeria textile waste to consumption rather than production has an implication on the waste management practices in all the states in Nigeria including Edo. The change in the consumption of imported textiles implies that waste management systems need to handle textile commodities with varied material compositions, chemical treatments, and recyclability properties that are not similar to the locally produced textiles that were predominant in the past.

Recent studies of waste management policies and practices and the population health outcomes in developing nations offer topical background information on why the challenges or opportunities in Edo State are important. The last systematic reviews and meta-analyses published in 2010-2023 are intended to summarize the current evidence, discover effective interventions, and evaluate the effects of the policy on the health of the population in the developing world and cover the critical gaps in the systematic synthesis to guide evidence-based policymaking. Such expanded lessons can be used to guide the development of textile waste management systems in Edo State.

The lack of documentation of the existing waste management in Edo State is both a gap in knowledge and an opportunity for the state to adopt monitoring and documentation systems that can facilitate the development of evidence-based policies. The effectiveness of policy interventions can be measured by systematic documentation of current practices, which can be used to identify areas requiring improvement.

7.3 Comparative Insights: Kaduna vs. Edo

The experience of the textile industry in Kaduna, compared with the opportunities in Edo State shows valuable lessons concerning various approaches to textile industry development and the consequences of these approaches to waste management and the implementation of a circular economy. These comparative lessons emphasize the possibility of learning through historical experience as well as the necessity to customize lessons to modern circumstances and issues.

The experience of Kaduna shows both advantages and risks in the long run of the development of the large-scale textile industry. The historical performance of the Kaduna textile industry in terms of offering jobs and enhancing the economic growth of the region demonstrates the impact that the activities of the textile industry can have on the development goals of the state. Nonetheless, the later downward trend and the related environmental legacies proves the significance of long-term sustainability and environmental management as the main factor to take into consideration during the planning of industrial development.

The schedule gap between the industrial development in Kaduna and the emerging opportunities in Edo sets various contexts to implement circular economy approaches. The textile industry of Kaduna grew at a time when the environmental factor was not a primary focus of the industrial policy, and the growth of the textile industry in Edo State is occurring in an environment where the concept of a circular economy and environmental sustainability are being seen as integral parts of the strategy of industrial development.

Infrastructural and institutional backgrounds also vary greatly between the presence of the Kaduna experience in history and the modern state of Edo. The textile industry of Kaduna was built in the environment of the growth of industrial infrastructure and the governmental encouragement of the import substitution industrialization. The development of Edo State is taking place in a situation where industrial infrastructure is limited but could have a higher number of options to modern technologies and global best practices of sustainable industrial growth.

There exist similarities and differences between the two cases in market contexts. Both Kaduna in the past, and Edo in the present are facing issues pertaining to the competition with imported textiles and the necessity to create competitive advantages on both local and possibly international markets. Nonetheless, there are current market prospects of sustainable and circular economy solutions, which could give Edo State market positioning opportunities unattainable in the prime development years of Kaduna.

The experience of Kaduna with the policy interventions can offer valuable insights to the development planning of Edo State. The short-term failure of several revival programs in Kaduna underscores the need to adopt broad, long-term policy strategies that are multi-dimensional in response to the competitiveness of industries in terms of environmental sustainability, technological modernisation, and market expansion.

The environmental and waste management issues can be another area of Edo State that can learn the experience of Kaduna and apply more sustainable strategies at the very beginning. The textile industry environmental legacies at Kaduna degrade show the cost of improper environmental planning in the long-term and the significance of implementing the environmental management with industrial development policy.

7.4 Potential Circular Economy Pathways for Edo

The status of Edo State as a developing textile and fashion hub provides the opportunity to apply the principles of the circular economy at the initial phases of industry development, which may help to prevent certain environmental issues which the established textile centers have and create competitive advantages, premised on the principles of sustainability.

The implementation of the principles of a circular economy in the development strategy of the textile industry of Edo State may take advantage of modern international tendencies towards sustainable fashion and the use of circular business models. Studies have shown that approximately 70% of the research focuses on waste management practices such as reuse and recycling and the shift to a circular economy, indicating substantial international momentum that Edo State could follow to receive technical support, funding, and market opportunities.

Design-based circular economy strategies constitute one of the most promising avenues in the case of Edo State, as the state has the potential to grow textile and fashion operations based on the principles of circular design at its core, as opposed to making existing linear systems circular. The focus on the design to be circular may position the textile sector in Edo State to cater to both the domestic market that would desire a sustainable alternative, and possibly the export market that would have a growing need of sustainably-produced textiles.

Another important avenue through which the implementation of the circular economy can be done in Edo State is through technology adoption and innovation. The emergence of textile activities in the state is accompanied by the rapid progress of textile recycling technologies, digital supply chain management systems, and circular business model innovations, which were not present at the previous stages of the development of the textile industry in Nigeria.

Circular economy development based on community and inclusive methods may be of particular interest to the Edo State as Nigeria has a tradition of community-based economic activities and needs to ensure that industrial development serves the needs of the local population. More inclusive and locally-adapted development pathways might be developed through circular economy strategies that incorporate informal sector activities and conventional textile practices.

The policy integration is an important channel towards facilitating the development of the circular economy in Edo State. Aligning industrial development policy with environmental management, waste management, and circular economy goals at the initial stages of policy development might produce more consistent and efficient forms of policy frameworks than trying to retrofit environmental considerations into current industrial policies.

The partnership and collaboration measures may help Edo State to find technical expertise, financial resources and market opportunities to implement the circular economy successfully. Capacity building and knowledge transfer could be assisted through partnerships with international organizations, other states in Nigeria, players in the private sector, and academic institutions sharing costs and risks of implementation.

The development timeframe of the textile industry in Edo State opens the opportunities to apply the principles of a circular economy that would be consistent with current global policy trends and market needs and could lead to the creation of competitive advantages due to sustainability credentials that would be able to support not only the positioning in the domestic market but also the export development.

CHAPTER 8. META-ANALYSIS FINDINGS

8.1 Aggregated Evidence from Literature Review

Upon reviewing literature on textile waste management and implementation of the circular economy, many patterns and findings are found to exist in a consistent manner, which has significant implications to policy formulation in Nigeria and within the particular context of the development of Edo State. The combination of evidence born out of many studies and contexts offers the insight that goes beyond the case studies and draws attention to the areas that require further research.

The reviews of textile waste management literature indicate that there is a substantial focus of the research on the framework of developed countries, and less is said about the experience of developing countries. Considering extensive systematic literature review which encompassed examination of 58 papers which were published in scholarly journals within the past 6 years it is clear that the number of studies performed in developing economies, where the majority of textile manufacturing has been based, have very limited study. This research gap not only poses a challenge to evidence-based policy development in such settings as Nigeria, but also creates the opportunity of adding to the international body of knowledge.

It is seen that the evidence on the topic is always consistent in pointing out infrastructure shortcomings as one of the key limitations to the efficacy of textile waste management in developing nations. The literature in various settings shows that the existing systems of waste collection, the lack of recycling technologies, and the lack of treatment facilities pose substantial obstacles to the adoption of the circular economy strategies. Such infrastructure limitations seem especially to play a critical role in sub-Saharan Africa, such as in Nigeria.

The themes of stakeholder coordination and institutional capacity are used throughout the literature, and all the studies report ineffective institutional arrangements as obstacles to successful textile waste management. The evidence indicates that the implementation of a circular economy needs to be coordinated at several government levels, the integration of both formal and informal sector operations, and long-lasting institution capacity building initiatives.

Another sphere where the cumulative evidence shows the similar trends is the economic incentives and the financing mechanisms. Literature on various settings finds the absence of economic incentives to behave in a circular economy to be a key obstacle to its advancement, and successful examples of such innovations tend to entail new approaches to financing the needs of moving to a more circular system.

The summary of the evidence also demonstrates a great diversity in efficacy of various policy strategies in various situations, which implies the necessity to adapt the strategies of a circular economy to local circumstances and not to take universal solutions. This observation is especially applicable to Nigeria, where different conditions of the region and institutional abilities demand specific strategies.

8.2 Patterns and Trends Across Studies

The patterns and trends analysis of the literature reviewed shows that there are several valuable insights related to the development of the textile waste management research and to the factors that influence the success of the implementation of the circular economy. Such trends guide the research priorities as well as policy development strategies.

The interest in textile waste management in research has grown significantly in the last ten years and the recent systematic reviews show significant increase in the volumes of publications. Nevertheless, geographical distribution and focus on research topics has not been equally spread with little emphasis on developing country settings and policy implementation issues.

According to geographic dispersion of research, there is a high concentration in European and North American settings as well as little representation of African and other developing countries experiences. Such a geographic bias of research coverage presents policy makers in such countries as Nigeria with difficulties in making use of findings of other contexts and limited evidence that is locally relevant.

The approaches to methodology in studies demonstrate that growing sophistication is observed, and more systematic reviews methodologies are used, as well as approaches based on life cycle assessment and integrated assessment frameworks. The literature however displays scant application of the policy evaluation methods and the long term impact assessment methods, which would prove useful in the determination of the policy effectiveness.

As can be seen, temporal tendencies in research focus point to the development of evolutionary trends of highly technical methods of recycling technologies to more comprehensive methods that take social, economic, and policy aspects of textile waste management. This gradual move towards systems thinking approaches offers superior avenues on entire policy formulation.

The evidence shows that renewed interest in the principles of the circular economy is being paid to the research in the field of the management of textile waste, and the studies indicate that there is an increased awareness of the fact that the system of waste management cannot be discussed outside the context of the overall changes in production and consumption system. This tendency to systems approaches conforms to the current policy demands but demands institutional abilities that have been weak in developing countries settings.

The studies on policy effectiveness show contradictory findings in various settings, and the success of policy implementation largely relies on the state of affairs, institutional capacities, and approaches to stakeholder engagement. This tendency implies the need to find adaptive management strategies permitting the learning and adaptation throughout the implementation.

8.3 Comparative Effectiveness of Policy Models

The meta-analysis provides significant information on comparative usefulness of various policy strategies used to handle textile waste and the application of the circular economy, but the number of serious policy evaluations is minimal, which limits the power of conclusions, which could be made.

Extended Producer Responsibility (EPR) frameworks are the most widely researched policy mechanism, and in general, have favorable assessments in the situation where regulatory enforcement capacity is high. Nevertheless, there is an indication that the use of EPR is highly conditional on the capacity of institutions and enforcement policies that are likely to restrict applicability in a situation with weak regulatory frameworks.

There are varied patterns of effectiveness of regulatory approaches in various contexts. Research studies show that command-and-control regulations may be effective with proper enforcement capacity and stakeholder compliance systems but may not be easily implemented in developing nations with low regulatory capacity.

The various economic incentive strategies, such as subsidies, tax incentives, and market-based strategies, hold promise, but must be carefully designed to prevent the unintended outcomes. The indications are that economic incentives will be the most effective in the presence of regulatory frameworks and capacity building support.

The voluntary and industry self-regulation strategies demonstrate poor performance as independent policy strategies but can be used to enhance the success of the policy when combined with compulsory requirements and accountability measures. The data indicate that voluntary strategies are more efficient in the situation when the industry is highly organized and coordinated among stakeholders.

Multi-stakeholder partnership strategies demonstrate good outcomes in various settings but involve considerable coordination effort and commitment in the long-term by involved organizations. The argument is that effective partnerships have to be characterized by effective governance mechanisms, matched incentives, and mobilization of resources.

The community-based strategies are especially prospective in the developing country setting, as informal economic activity and community mobilization can be the basis of localized adaptation of circular economy development. Nevertheless, the process of community-based scaling to gain considerable environmental implications is not an easy task.

8.4 Gaps in Research and Knowledge

The meta-analysis shows that there are a number of important gaps in the research and knowledge that restrict the evidence base on policy development and provide the focus on the research investment in the future. The gaps are especially acute in terms of the developing countries background and have significant policy development consequences in Nigeria.

The greatest limitation is the geographic research gaps whereby very little research has been done in developing economies where the majority of the textile manufacturing is done. The challenges of this geographic bias are that it adds difficulties to the policy makers who have no locally relevant evidence bases and have to use the results of other contexts.

The methodological gaps are that policy evaluation methodologies have been used minimally, long-term impact assessment techniques, and integrated assessment frameworks where several aspects of sustainability are assessed at the same time. The hegemony of case studies and little use of comparative methodology limits the knowledge on the influence of factors on the success of policies in various contexts.

The gap in sectoral integration indicates the lack of concern over the interlinkages between textile waste management on the one hand and the overall industrial policy, environmental management and economic development goals on the other. Such low levels of integration in research are similar to the institutional coordination difficulty in policy implementation.

The gaps in the stakeholder perspective consist of the lack of interest in the roles of the informal sector, the community, and small-scale enterprise experiences in the process of building a circular economy. These gaps restrict the knowledge of inclusive approaches to the development of a circular economy due to the significance of the informal sector operations in developing countries.

The lack of studies that would trace the outcomes of policy implementation over the long term is a gap of the long-term impact assessment. The bulk of the literature available is devoted to the short-term processes of implementation as opposed to the effectiveness and sustainability of policy interventions in the long run.

The gaps in innovation and technology transfer involve lack of research on how circular economy technologies can be applied to the situation in developing countries and how effective technology transfer and local adaptation processes are influenced by factors. These discontinuities are especially applicable to such countries as Nigeria that aim to implement and transform technologies developed in other frameworks.

The lack of research regarding the economic aspects of circular economy transitions is reflected in financing and economic analysis gaps: the costs-benefit analysis of the various policy options and the evaluation of the financing mechanisms to support the development of the circular economy in resource-constrained environments.

Gender and social equity disparities incorporate the lack of careful consideration of how the textile waste management policy affects the various social groups differently and the probability of the circular economy strategies to mitigate or result in contemporary disparities. Since women constitute a high percentage of the workforce in the textile industry, the gaps restrict the knowledge of inclusive policy-making strategies.

CHAPTER 9. POLICY RECOMMENDATIONS

9.1 Institutional and Governance Reforms

Multi-Level Governance Architecture

Nigeria requires a comprehensive restructuring of its institutional architecture to effectively address textile waste management and circular economy implementation. The current fragmentation across federal, state, and local government levels creates coordination gaps that undermine policy effectiveness and limit the potential for scaled circular economy interventions. Edo State's development trajectory provides an opportunity to pioneer innovative governance approaches that can subsequently inform national-level reforms.

The establishment of a dedicated Circular Economy Authority at the federal level, with state-level counterparts, represents a critical institutional reform priority. This authority should possess mandate and capacity to coordinate across sectors, integrate policy domains, and provide technical assistance to state and local governments. The authority's structure should incorporate multi-stakeholder governance principles, including representation from industry associations, civil society organizations, academic institutions, and informal sector networks.

Institutional capacity building requires systematic investment in technical expertise, policy analysis capabilities, and implementation management systems across all government levels. Current institutional capacities in environmental management and industrial policy are insufficient for the complex coordination requirements of circular economy implementation. Capacity building programs should emphasize systems thinking approaches, stakeholder engagement methodologies, and adaptive management principles that enable learning and adjustment during implementation.

The integration of informal sector actors into formal governance structures represents a particular priority given the significant role of informal networks in current textile waste management practices. Institutional reforms should create formal mechanisms for informal sector representation in policy development processes while providing pathways for informal enterprises to transition to formal status where appropriate.

Regulatory Framework Integration

Contemporary regulatory frameworks for environmental management, industrial policy, and waste management operate with limited coordination, creating regulatory gaps and implementation challenges that affect circular economy development. Regulatory integration requires comprehensive review and reform of existing frameworks to eliminate inconsistencies, reduce administrative burdens, and create positive incentives for circular economy behavior.

Extended Producer Responsibility (EPR) framework development represents a priority regulatory reform that can create systematic incentives for circular design and end-of-life recovery. However, the textile industry can learn from the successes of e-waste regulations, which improved recycling rates through extended producer responsibility and support the circular economy. Nigeria's EPR framework should adapt international best practices to local conditions while addressing the particular challenges of import-dominated textile markets and limited formal waste management infrastructure.

Environmental impact assessment requirements for textile industry operations should incorporate circular economy principles and life-cycle thinking to ensure that environmental management considers both

production and waste management phases. Current environmental assessment processes focus primarily on production-phase impacts and provide limited attention to waste generation and end-of-life management implications.

Trade policy integration with circular economy objectives requires coordination between ministries responsible for trade policy and environmental management. Current trade policies affecting textile imports should be reviewed to ensure consistency with domestic circular economy development objectives while complying with international trade obligations.
Monitoring and Evaluation Systems

Effective circular economy governance requires comprehensive monitoring and evaluation systems that can track progress toward policy objectives while identifying implementation challenges and adaptation opportunities. Current monitoring systems for both environmental management and industrial policy provide limited coverage of circular economy indicators and lack integration across policy domains.

The development of national and state-level circular economy indicators should follow international frameworks while incorporating locally-relevant measures that reflect Nigeria's specific conditions and priorities. Indicator systems should address environmental outcomes (waste generation, resource efficiency, pollution reduction), economic outcomes (employment, revenue generation, cost savings), and social outcomes (community health, environmental justice, informal sector integration).

Data collection and management systems require significant upgrading to support evidence-based policy development and implementation monitoring. Current data limitations affecting textile waste management reflect broader challenges in environmental and economic data systems that limit policy analysis and evaluation capabilities.

9.2 Circular Economy Integration: Reuse, Recycling, and Upcycling

Reuse System Development

Systematic development of textile reuse systems represents a high-priority intervention that can address waste management challenges while creating economic opportunities and extending product lifecycles. Textile manufacturers are recognizing the value of resources, thereby executing CE practices such as resource recovery, recycling waste, and use of sustainable and renewable materials. Reuse systems require coordination across multiple stakeholder groups and integration with both formal and informal sector activities.

Community-based reuse initiatives should receive priority support through technical assistance, capacity building, and market development programs. Existing informal networks for textile collection, sorting, and redistribution provide foundations for expanded reuse systems, but require institutional support and market integration to achieve scale and sustainability.

Digital platforms and technologies can significantly enhance reuse system efficiency by connecting supply and demand, facilitating quality assessment, and supporting logistics coordination. Investment in

digital infrastructure for reuse systems should be coordinated with broader digital economy development initiatives to maximize synergies and minimize implementation costs.

Quality standards and certification systems for reused textiles can support market development by addressing consumer concerns about product quality and safety. Standards development should balance consumer protection objectives with accessibility for informal sector participants and small-scale enterprises.

Recycling Infrastructure and Technology

Recycling system development requires substantial investment in both technological infrastructure and human capacity, with particular attention to technologies appropriate for Nigeria's economic and institutional context. Making textiles circular can have an immense impact. The development of textile production linked to reverse logistics capacities could improve the resilience of domestic textile systems while addressing waste management challenges.

Mechanical recycling technologies offer the most accessible pathway for near-term recycling system development, requiring lower capital investment and technological sophistication compared to chemical recycling approaches. However, mechanical recycling systems require careful attention to feedstock quality and sorting systems to ensure processing effectiveness and output quality.

Regional recycling hub development can achieve economies of scale while serving multiple states and reducing transportation costs. Edo State's geographic position and emerging industrial infrastructure make it a promising location for regional recycling hub development that could serve broader West African markets.

Technology transfer and adaptation programs should emphasize South-South cooperation and technology adaptation approaches that consider local conditions and constraints. International technology partnerships should include capacity building components that enable local technology adaptation and maintenance capabilities.

Upcycling and Value-Added Processing

Upcycling represents a particularly promising pathway for creating economic value from textile waste while addressing environmental objectives. Upcycling activities can leverage Nigeria's existing textile crafts traditions and creative industries to create higher-value products from waste materials.

Design innovation programs should connect textile waste processors with fashion designers, artists, and creative entrepreneurs to develop innovative upcycling approaches. These programs should provide business development support, market access facilitation, and technical assistance to scale successful upcycling enterprises.

Skills development programs for upcycling should target both formal educational institutions and community-based training programs to build technical capabilities across different segments of the

creative economy. Training programs should emphasize both technical skills and business development capabilities.

Market development for upcycled products requires coordinated demand-side interventions including public procurement programs, retailer engagement initiatives, and consumer awareness campaigns that build appreciation for upcycled textile products.

9.3 Industry Engagement and Extended Producer Responsibility

Stakeholder Engagement Framework

Effective industry engagement requires systematic approaches that recognize the diversity of textile industry actors, from large importers and retailers to small-scale manufacturers and informal sector traders. Engagement frameworks should provide multiple pathways for participation while ensuring that all significant stakeholder groups have voice in policy development processes.

Industry associations play crucial roles as intermediaries between government agencies and individual enterprises, providing channels for policy communication and feedback while building consensus among industry participants. Strengthening industry associations through capacity building and institutional support can enhance their effectiveness in supporting circular economy implementation.

Multi-stakeholder platforms should bring together industry representatives, government agencies, civil society organizations, and academic institutions to foster collaboration and coordinate circular economy initiatives. Platform governance structures should ensure balanced representation while maintaining focus on practical implementation outcomes.

Regular stakeholder consultation processes should be institutionalized through formal requirements for stakeholder input in policy development, implementation planning, and performance evaluation. Consultation processes should include mechanisms for informal sector participation and community input.

Extended Producer Responsibility Design and Implementation

EPR framework design for Nigeria's textile sector must address the particular challenges of import-dominated markets, limited formal waste management infrastructure, and significant informal sector involvement. Restrict the export of textile waste and promote sustainable textiles globally · Incentivising circular business models, including reuse and repair sectors represents key elements of comprehensive EPR frameworks.

Producer responsibility scope should encompass both domestic manufacturers and importers to ensure comprehensive coverage while avoiding competitive distortions. Clear definitions of producer responsibilities and waste coverage are essential to prevent circumvention and ensure effective implementation.

Financing mechanisms for EPR should balance cost recovery objectives with affordability for small and medium enterprises while creating incentives for circular design and sustainable business practices. Fee structures should incorporate environmental performance indicators that reward circular economy behavior.

Implementation should follow phased approaches that begin with pilot programs and demonstration projects before scaling to comprehensive coverage. Pilot programs should focus on specific product categories or geographic regions to enable learning and system refinement.

Business Model Innovation Support

Circular business model development requires both regulatory frameworks that enable innovative approaches and support mechanisms that address market failures and implementation barriers. Business model innovation support should target both established enterprises seeking to transition to circular approaches and new enterprises building circular models from inception.

Incubation and accelerator programs specifically focused on circular economy enterprises can provide targeted support for business model development, market access, and scaling. These programs should connect emerging enterprises with established industry actors, financial institutions, and market opportunities.

Financial mechanism development should address the particular capital requirements and risk profiles of circular economy enterprises, including longer payback periods and novel revenue streams. Innovative financing approaches including blended finance, impact investment, and revenue-based financing may be appropriate for circular economy business model support.

Market access facilitation should include both domestic and export market development, with particular attention to connecting Nigerian circular economy enterprises with international markets that value sustainable production approaches.

9.4 Educational and Capacity-Building Strategies

Formal Education Integration

Integration of circular economy principles into formal education curricula represents a long-term strategy for building systematic capacity and cultural change toward sustainability. Educational integration should span multiple levels from primary education through higher education and professional development programs.

Higher education programs in engineering, business, environmental management, and design should incorporate circular economy principles as core curriculum components rather than specialized electives. Interdisciplinary approaches that connect technical, economic, and social dimensions of the circular economy are particularly valuable.

Technical and vocational education programs should emphasize practical skills for circular economy implementation including waste processing technologies, repair and refurbishment techniques, and sustainable design approaches. These programs should maintain strong connections with industry to ensure relevance and employment outcomes.

Research capacity building in higher education institutions should prioritize circular economy research and policy analysis capabilities. Research capacity building should include both technical research capabilities and policy analysis and evaluation methodologies.

Professional Development and Skills Building

Professional development programs should target multiple stakeholder groups including government officials, industry managers, civil society organizations, and community leaders. Programs should emphasize both technical knowledge and implementation capabilities.

Government capacity building should focus on policy analysis, stakeholder engagement, program management, and performance monitoring capabilities. Training programs should include both domestic and international components to facilitate learning from global experience while adapting to local contexts.

Industry training programs should address both technical aspects of circular economy implementation and business model innovation approaches. Training should be tailored to different industry segments and enterprise sizes to ensure relevance and accessibility.

Community-based capacity building should build on existing traditional knowledge and practices while introducing new techniques and approaches. Community programs should emphasize participatory approaches that respect local knowledge while building new capabilities.

Public Awareness and Behavior Change

Public awareness campaigns should address multiple target audiences with tailored messaging that reflects different knowledge levels, cultural contexts, and behavioral influences. Increase public awareness of climate change, with targeted campaigns to encourage the general population and actors engaged in industrial production to adopt greener practices.

Consumer behavior change initiatives should address both consumption decisions and disposal behavior, emphasizing practical actions that individuals and households can take to support circular economy objectives. Campaigns should provide clear information about product alternatives and disposal options.
Cultural integration approaches should connect circular economy principles with traditional Nigerian values and practices related to resource conservation, community cooperation, and environmental stewardship. Cultural framing can enhance message resonance and behavioral uptake.

School-based programs should engage students as change agents within families and communities while building long-term cultural change toward sustainability. School programs should combine classroom learning with practical demonstration projects and community engagement activities.

9.5 Regional and Global Collaboration Opportunities

West African Regional Integration

Regional collaboration within West Africa offers significant opportunities for scaling circular economy approaches while addressing common challenges related to textile waste management and sustainable development. This project will work in Ghana, Kenya, Pakistan and Tunisia, acknowledging the high amounts of used textile imports in those countries, demonstrating existing international frameworks for regional collaboration.

Economic Community of West African States (ECOWAS) frameworks should be leveraged to facilitate regional coordination on textile waste management and circular economy development. Regional policy harmonization can reduce trade barriers for circular economy products while establishing common standards and approaches.

Regional infrastructure development should emphasize shared facilities that can achieve economies of scale while serving multiple countries. Regional recycling hubs, training centers, and research facilities can maximize resource utilization while building regional capacity.

Knowledge sharing networks should facilitate learning exchange across countries while building regional expertise and capabilities. Regular regional conferences, technical exchanges, and joint research initiatives can strengthen collaboration and accelerate implementation.

International Partnership Development

International partnerships should emphasize South-South cooperation and technology transfer approaches that consider comparable development contexts and conditions. Clarify EU used textile trade flow predictions highlights the importance of understanding international trade implications of circular economy policies.

Multilateral organization partnerships should leverage existing frameworks including UN Environment Programme, World Bank, and African Development Bank programs focused on circular economy and sustainable development. These partnerships can provide technical assistance, financing, and knowledge sharing opportunities.

Bilateral cooperation agreements should include circular economy and textile waste management components that facilitate technology transfer, capacity building, and market access. Partnerships with countries having advanced circular economy experience can accelerate learning and implementation.

Private sector partnerships should connect Nigerian enterprises with international markets, technologies, and financing while building export capabilities for circular economy products and services.

Climate Finance and International Funding

International climate finance mechanisms present significant opportunities for supporting circular economy implementation while addressing climate change mitigation and adaptation objectives. Textile circular economy initiatives can contribute to multiple climate objectives including emissions reduction, resource efficiency, and resilience building.

Green Climate Fund and other multilateral climate financing mechanisms should be systematically accessed to support large-scale circular economy infrastructure development. Project development capabilities and proposal preparation support may be necessary to effectively access these resources.

Carbon market opportunities including both compliance and voluntary carbon markets may provide revenue streams for circular economy initiatives that achieve verified emissions reductions. Carbon project development requires technical capabilities and monitoring systems that may require capacity building support.

Impact investment and sustainable finance mechanisms are increasingly available for circular economy initiatives that demonstrate both environmental and social impact. Accessing these financing sources requires business model development and impact measurement capabilities.

CHAPTER 10. DISCUSSION

10.1 Implications for Nigeria's Sustainable Development Goals

The implementation of comprehensive textile waste management and circular economy policies directly advances multiple Sustainable Development Goals (SDGs), creating synergies that can accelerate Nigeria's progress toward the 2030 Agenda while addressing pressing environmental and economic challenges. The country's textile waste challenge directly impacts SDG 6 (Clean Water and Sanitation), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action), demonstrating the interconnected nature of textile waste management with broader sustainable development objectives.

SDG 8: Decent Work and Economic Growth

Circular economy approaches to textile waste management offer substantial potential for employment generation across multiple skill levels and economic sectors. The development of comprehensive reuse, recycling, and upcycling systems can create employment opportunities that range from low-skilled waste collection and sorting activities to high-skilled design and technology positions. For Nigeria, with its significant youth population and employment challenges, the job creation potential of textile circular economy initiatives represents a crucial development opportunity.

The quality of employment generated through circular economy initiatives requires careful attention to ensure alignment with decent work principles. Informal sector integration strategies should emphasize formalization pathways that provide social protection, skills development, and income security while maintaining the flexibility and accessibility that make informal sector participation attractive.

Gender dimensions of employment creation in textile circular economy are particularly significant given the high representation of women in both textile production and waste management activities. Policy implementation should explicitly address gender equity objectives while building on women's existing knowledge and capabilities in textile-related activities.

SDG 12: Responsible Consumption and Production

The textile sector represents one of the most pressing challenges for sustainable consumption and production globally, with fast fashion and linear production models driving massive resource consumption and waste generation. Nigeria's policy development in this sector can contribute to global sustainable consumption and production objectives while addressing domestic development priorities.

Resource efficiency improvements through circular economy approaches can significantly reduce the environmental footprint of textile consumption in Nigeria while creating economic value from materials that would otherwise be wasted. The textile and clothing industry (T&C) is the second largest industry in the manufacturing sector. Currently, the industry operates on a linear model. Its value-chain is associated with several problems such as environment pollution, highlighting the urgent need for systemic transformation.

Consumer behavior change initiatives that promote sustainable consumption patterns can contribute to global efforts to reduce the environmental impact of textile consumption while building domestic markets for sustainable textile products. Educational campaigns and awareness programs should emphasize both individual behavior change and systemic solutions.

SDG 6: Clean Water and Sanitation

Textile production and waste disposal create significant impacts on water resources through both pollution and consumption pathways. Circular economy approaches that reduce textile waste generation and improve waste management practices can contribute to water resource protection while reducing treatment costs and health risks.

Water pollution prevention through improved textile waste management is particularly important in Nigeria, where water scarcity and quality challenges affect significant populations. Preventing textile-related water contamination can protect both surface and groundwater resources while reducing the costs of water treatment and healthcare.

Industrial water use efficiency improvements through circular design and production approaches can reduce pressure on water resources while lowering production costs. Water efficiency improvements are

particularly important given climate change impacts on water availability and the competition between different water uses.

SDG 13: Climate Action

The textile industry contributes significantly to greenhouse gas emissions through both production processes and waste management practices. The apparel industry contributes 10% of global carbon emissions, exceeding those from international flights, demonstrating the climate significance of textile sector transformation.

Emissions reduction through circular economy approaches can contribute to Nigeria's climate commitments under the Paris Agreement while creating co-benefits for air quality and public health. Systematic measurement and reporting of emissions reductions from circular economy initiatives can support access to climate finance and carbon market opportunities.

Climate adaptation benefits from circular economy approaches include reduced dependence on resource imports, increased economic resilience through resource efficiency, and community capacity building that enhances adaptive capacity. These adaptation co-benefits are particularly important for Nigeria given its vulnerability to climate change impacts.

SDG 3: Good Health and Well-Being

Public health implications of textile waste management represent a significant but underappreciated dimension of sustainable development impacts. Poor textile waste management practices can contribute to air and water pollution, soil contamination, and vector breeding that affect community health outcomes.

Occupational health improvements through better working conditions in textile recycling and processing can contribute to health and safety objectives while supporting decent work goals. Investment in occupational health and safety systems for circular economy enterprises is essential for sustainable development.

Community health protection through reduced environmental pollution from textile waste can contribute to broader public health objectives while reducing healthcare costs and improving quality of life. Community health co-benefits should be systematically measured and communicated to build support for circular economy initiatives.

10.2 Relevance to Climate Action and Public Health

Climate Mitigation Potential

The greenhouse gas emissions profile of textile production and waste management creates substantial opportunities for climate mitigation through circular economy approaches. Lifecycle emissions from textile products include significant contributions from raw material production, manufacturing processes,

transportation, and end-of-life disposal that can be reduced through systematic circular economy implementation.

An extra $20-30 billion annually is needed to make the textile value chain more sustainable, with 60% focused on energy, water, and waste issues alone. This investment requirement highlights both the scale of the challenge and the potential for emissions reduction through comprehensive circular economy approaches.

Quantifying emissions reduction potential from specific policy interventions requires lifecycle assessment approaches that consider all phases of textile product lifecycles. Systematic emissions measurement and reporting can support access to climate finance while demonstrating the climate relevance of textile circular economy initiatives.

Carbon sequestration opportunities through natural fiber production and processing can contribute to climate mitigation while supporting rural economic development. Integration of carbon sequestration considerations into textile circular economy planning can create additional revenue streams while enhancing climate benefits.

Public Health Co-Benefits

The health co-benefits of improved textile waste management extend beyond direct pollution reduction to include occupational health improvements, community environmental quality enhancement, and reduced exposure to hazardous substances. These health co-benefits can provide substantial economic value that justifies investment in circular economy approaches.

Air quality improvements from reduced textile waste incineration and improved production processes can contribute to respiratory health outcomes while reducing healthcare costs. Air quality monitoring and health impact assessment can quantify these benefits and support policy justification.

Water quality protection through reduced textile pollution can prevent waterborne diseases while protecting ecosystem health. Water quality monitoring programs should track textile-related pollution indicators to measure policy effectiveness and health impact.

Chemical exposure reduction through safer textile production and processing approaches can prevent both occupational and community health impacts from hazardous substances. Chemical safety regulation and monitoring should be integrated with circular economy policy implementation.

Environmental Justice Considerations

Environmental justice implications of textile waste management policies require systematic attention to ensure that environmental and health benefits are equitably distributed while avoiding displacement of environmental burdens to vulnerable communities. Current patterns of textile waste disposal often disproportionately affect low-income communities and communities of color.

Community engagement in policy development and implementation can ensure that environmental justice concerns are addressed while building local capacity and ownership. Participatory approaches to policy development should include mechanisms for meaningful community input and benefit-sharing.

Cumulative impact assessment should consider the interaction between textile waste management policies and other environmental and social stressors affecting vulnerable communities. Policy implementation should address cumulative impacts while providing net benefits to affected communities.

10.3 Risks, Challenges, and Mitigation Strategies

Implementation Risks and Mitigation Approaches

Policy implementation risks in the Nigerian context include institutional capacity constraints, coordination challenges across government levels, limited financial resources, and political economy factors that may affect policy sustainability. examine the factors that challenge or motivate textile and apparel suppliers' implementation of circular economy (CE) practices in developing countries, providing insights into implementation barriers.

Institutional capacity risks can be mitigated through systematic capacity building programs, technical assistance partnerships, and gradual implementation approaches that build capabilities over time. Phased implementation can reduce capacity demands while enabling learning and system refinement.

Coordination risks across government levels require clear institutional arrangements, communication protocols, and incentive alignment that encourage cooperation rather than competition. Multi-level governance frameworks should specify roles and responsibilities while providing mechanisms for dispute resolution.

Financial resource constraints require diversified financing strategies that combine domestic resource mobilization with international financing while building revenue generation capabilities through circular economy activities. Financing strategies should address both upfront capital requirements and ongoing operational costs.

Market Development Challenges

Market development for circular economy products and services faces challenges related to consumer acceptance, price competitiveness, quality assurance, and distribution systems. These market challenges require coordinated demand-side and supply-side interventions that address both immediate barriers and long-term market development objectives.

Consumer acceptance challenges can be addressed through awareness campaigns, product certification systems, and demonstration projects that build familiarity and trust. Consumer education should emphasize both environmental benefits and product quality to build sustainable demand.

Price competitiveness challenges reflect the failure of conventional markets to account for environmental costs and benefits. Policy interventions including subsidies, tax incentives, and regulatory requirements can help level the playing field while building market scale.

Quality assurance systems should establish standards and certification processes that protect consumers while supporting market development. Standards development should balance quality objectives with accessibility for small-scale producers and informal sector participants.

Technology and Innovation Challenges

Technology adaptation and innovation challenges include limited access to appropriate technologies, inadequate technical capabilities, and insufficient research and development infrastructure. Technology challenges require both technology transfer initiatives and domestic innovation capacity building.

Technology transfer challenges can be addressed through international partnerships, South-South cooperation programs, and technology adaptation initiatives that modify technologies for local conditions. Technology partnerships should include capacity building components that enable local maintenance and improvement.

Innovation capacity building requires investment in research and development infrastructure, technical education, and innovation support systems. University-industry partnerships can bridge research and application while building local innovation capabilities.

Intellectual property considerations may affect technology access and adaptation possibilities. Policy frameworks should balance innovation incentives with technology access objectives while supporting domestic capability development.

Social and Cultural Adaptation Challenges

Cultural acceptance of circular economy practices may face resistance related to traditional consumption patterns, social status considerations, and unfamiliarity with new approaches. Cultural adaptation challenges require engagement approaches that respect traditional values while promoting beneficial change.

Social status concerns related to reused or recycled products can be addressed through product design, marketing strategies, and cultural messaging that position circular economy products as desirable and fashionable. Celebrity endorsements and social influencer engagement may support cultural change.

Traditional practice integration should build on existing cultural practices related to resource conservation, repair, and reuse while introducing new techniques and approaches. Respecting traditional knowledge while promoting innovation can enhance acceptance and effectiveness.

Community leadership engagement is essential for building social acceptance and overcoming resistance to change. Traditional leaders, religious leaders, and community organizations can play important roles in promoting circular economy approaches.

CHAPTER 11. CONCLUSION

11.1 Summary of Key Insights

This meta-analytical investigation of textile waste and circular economy opportunities in Nigeria reveals a complex landscape of challenges and opportunities that extends far beyond simple waste management concerns to encompass fundamental questions of sustainable industrial development, environmental justice, and economic transformation. The research demonstrates that textile waste management cannot be effectively addressed through isolated technical interventions but requires comprehensive policy frameworks that integrate environmental, economic, and social dimensions while building on existing capabilities and addressing systemic constraints.

The global literature synthesis establishes the magnitude of textile waste challenges, with the fashion industry contributing 20% of all global wastewater and releasing approximately 500,000 tons of microfibers into water systems annually. More critically, the research reveals significant geographic bias in existing knowledge, with very limited studies conducted in developing economies where most textile manufacturing occurs, creating substantial evidence gaps for policy development in contexts like Nigeria.

Nigeria's textile landscape presents a compelling case of industrial transformation, from the historical success of Kaduna's textile sector that employed over 350,000 workers at its peak to the contemporary reality where textile industries in major centers had closed by the 1990s, leaving the country largely dependent on textile imports. This transformation fundamentally altered the composition and characteristics of textile waste in Nigeria, shifting from production-based waste streams with known material characteristics to consumption-based waste from imported textiles with diverse and often unknown compositions.

The comparative analysis between Kaduna's historical experience and Edo State's emerging opportunities illuminates different pathways for textile industry development and their implications for circular economy implementation. Kaduna's experience demonstrates both the potential benefits and long-term risks of large-scale textile industry development, while Edo State's contemporary context provides opportunities for implementing circular economy principles from the outset rather than retrofitting existing linear systems.

The meta-analysis findings reveal consistent patterns across global literature, including infrastructure deficits as major constraints in developing countries, the critical importance of stakeholder coordination and institutional capacity, and the need for economic incentives that align with circular economy objectives. Significantly, the research identifies mixed effectiveness of different policy approaches, with success heavily dependent on local conditions, institutional capacities, and stakeholder engagement strategies.

11.2 Lessons for Nigeria and Broader African Context

The Nigerian experience offers several important lessons that extend beyond national boundaries to inform broader African approaches to textile waste management and circular economy development. These lessons are particularly relevant given similar patterns of industrial development, institutional challenges, and environmental pressures across sub-Saharan African contexts.

Historical Industrial Development and Environmental Legacy

The trajectory of Nigeria's textile industry, exemplified by Kaduna's rise and decline, demonstrates both the potential and pitfalls of rapid industrial development without adequate attention to environmental sustainability and long-term planning. The environmental legacies of industrial decline—including abandoned facilities, chemical contamination, and disrupted waste management systems—continue to affect contemporary development efforts and highlight the importance of integrating environmental considerations into industrial policy from the outset.

For other African countries pursuing textile industry development, the Nigerian experience underscores the necessity of comprehensive planning that addresses both production and waste management dimensions simultaneously. The failure to develop adequate waste management systems during periods of industrial growth creates long-term environmental and economic burdens that can persist long after production activities have declined or relocated.

Informal Sector Integration and Inclusive Development

Nigeria's extensive informal sector networks for textile waste collection, processing, and redistribution demonstrate both the potential for circular economy approaches and the challenges of integrating informal practices with formal policy frameworks. The sophistication of existing informal systems suggests that effective circular economy policies must build on existing capabilities rather than attempting to replace informal activities with formal systems.

The lesson for broader African contexts is that circular economy development should emphasize inclusive approaches that recognize and support existing informal sector capabilities while providing pathways for formalization where appropriate. Policy frameworks that ignore or marginalize informal sector contributions are likely to face implementation challenges and may exacerbate existing inequalities.

Technology Transfer and Local Adaptation

The limited success of various technology transfer initiatives in Nigeria's textile sector highlights the importance of technology adaptation to local conditions and constraints. Simply importing technologies developed for different contexts without considering local infrastructure, skills, and market conditions has proven insufficient for sustainable technology adoption.

For other African countries, the lesson is that effective circular economy technology development requires emphasis on South-South cooperation, local adaptation capabilities, and gradual capacity

building rather than wholesale technology transfer from developed countries. Building domestic technological capabilities and adaptation capacity is essential for long-term sustainability of circular economy initiatives.

Multi-Level Governance and Coordination

Nigeria's experience with fragmented governance across federal, state, and local levels illustrates both the challenges and opportunities of multi-level governance for circular economy development. While coordination challenges create implementation difficulties, the diversity of governance levels also provides opportunities for experimentation, adaptation, and scaling of successful approaches.

The broader lesson for African contexts is that effective circular economy governance requires clear institutional arrangements, coordination mechanisms, and capacity building across multiple governance levels. Federal systems may face particular coordination challenges, but they also provide opportunities for subnational innovation and adaptation that can inform national policy development.

Regional Integration and Collaboration Opportunities

Nigeria's position within West African regional frameworks demonstrates the potential for regional approaches to circular economy development that can achieve economies of scale while addressing common challenges. Regional collaboration can facilitate technology sharing, market development, and capacity building while reducing individual country implementation costs.

For the broader African context, regional economic communities provide important frameworks for scaling circular economy approaches beyond individual country boundaries. Regional approaches are particularly valuable for addressing transboundary environmental challenges and building markets for circular economy products and services.

11.3 Pathways for Future Policy and Research

The analysis reveals several critical pathways for future policy development and research that can advance both practical implementation and scholarly understanding of circular economy approaches in developing country contexts.

Policy Development Priorities

Institutional capacity building emerges as the most fundamental policy development priority, requiring sustained investment in technical expertise, policy analysis capabilities, and implementation management systems across all levels of government. Future policy development should emphasize systems thinking approaches that can address the complex interactions between environmental, economic, and social dimensions of circular economy implementation.

Extended Producer Responsibility framework development represents a key policy innovation opportunity that can create systematic incentives for circular design while addressing the particular

challenges of import-dominated textile markets. Future EPR development should adapt international best practices to local conditions while incorporating informal sector integration and capacity building components.

Regional cooperation frameworks should be systematically developed to facilitate knowledge sharing, technology transfer, and market development across African countries. Regional approaches can achieve economies of scale while addressing common challenges and building collective capacity for circular economy implementation.

Research Priorities and Knowledge Gaps

Geographic research gaps represent the most significant limitation identified in the meta-analysis, with very limited studies conducted in developing economies despite their central role in global textile production and consumption. Future research should prioritize developing country contexts while building local research capacity and expertise.

Long-term impact assessment represents a critical research gap, with limited studies tracking policy implementation outcomes over extended time periods. Future research should emphasize longitudinal approaches that can assess the long-term effectiveness and sustainability of different policy interventions.

Sectoral integration research should address the interconnections between textile waste management and broader industrial policy, environmental management, and economic development objectives. Future research should employ integrated assessment approaches that consider multiple dimensions of sustainability simultaneously.

Gender and social equity research should examine the differential impacts of textile waste management policies on different social groups and the potential for circular economy approaches to address or exacerbate existing inequalities. This research is particularly important given the significant representation of women in textile sector employment.

Innovation and Technology Development

Technology adaptation research should focus on developing and testing technologies appropriate for developing country contexts, with particular emphasis on technologies that can integrate formal and informal sector activities. Future technology development should emphasize local adaptation capabilities and maintenance requirements.

Digital technology applications for circular economy should be explored, including digital platforms for waste tracking, supply chain transparency, and market development. Research should examine both technological possibilities and implementation constraints in developing country contexts.

Financing mechanism innovation should address the particular capital requirements and risk profiles of circular economy enterprises in developing countries. Research should examine innovative financing approaches including blended finance, impact investment, and revenue-based financing models.

Monitoring and Evaluation System Development

Indicator system development should create comprehensive frameworks for tracking circular economy progress that are appropriate for developing country contexts while enabling international comparison and learning. Future development should emphasize indicators that capture both environmental and social outcomes.

Impact measurement methodologies should be developed for assessing the effectiveness of different policy interventions while building local capacity for policy evaluation and adaptive management. Methodological development should emphasize participatory approaches that include stakeholder perspectives.

Data system development should address the fundamental data limitations that constrain evidence-based policy development and implementation monitoring. Future development should emphasize building sustainable data collection and management systems that can support long-term policy development.

International Cooperation and Knowledge Exchange

South-South cooperation mechanisms should be systematically developed to facilitate knowledge sharing and technology transfer between developing countries with comparable contexts and challenges. Future cooperation should emphasize peer learning and experience exchange rather than traditional technical assistance models.

Academic cooperation should build research capacity and expertise in developing country institutions while fostering collaborative research partnerships that can address shared challenges and build collective knowledge.

Policy learning networks should facilitate systematic sharing of implementation experiences and lessons learned across different policy contexts. Future network development should emphasize practical policy implementation insights and adaptive management approaches.

The pathways identified through this research demonstrate that effective circular economy development in African contexts requires comprehensive approaches that address technical, institutional, and social dimensions simultaneously while building on existing capabilities and addressing systemic constraints. Success will depend on sustained commitment to capacity building, stakeholder engagement, and adaptive management approaches that enable learning and improvement over time.

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CHAPTER 13. ANNEXES

Annex A: List of Studies Reviewed

A.1 Global Literature on Textile Waste Management

Study ID: GL001
Authors: Sandin, G., & Peters, G. M.
Year: 2018
Title: Environmental impact of textile reuse and recycling: A review
Journal: Journal of Cleaner Production
Volume/Pages: 184, 353-365
Study Type: Systematic Review
Geographic Focus: Global
Key Findings: Quantitative analysis of environmental benefits from textile reuse and recycling across different contexts
Methodology: Literature review with lifecycle assessment synthesis
Relevance Score: High - directly addresses circular economy approaches

Study ID: GL002
Authors: Zamani, B., Sandin, G., Svanström, M., & Peters, G. M.
Year: 2018
Title: Hotspot identification in the clothing industry using social life cycle assessment
Journal: International Journal of Life Cycle Assessment
Volume/Pages: 23(3), 536-546
Study Type: Empirical Research
Geographic Focus: Global
Key Findings: Social impacts concentrated in specific stages of textile value chains
Methodology: Social lifecycle assessment with input-output modeling
Relevance Score: High - addresses social dimensions of textile sustainability

Study ID: GL003
Authors: Roos, S., Sandin, G., Zamani, B., & Peters, G.
Year: 2015

Title: Environmental assessment of Swedish fashion consumption
Publisher: Mistra Future Fashion
Study Type: Empirical Research
Geographic Focus: Sweden
Key Findings: Quantified environmental impacts of fashion consumption patterns
Methodology: Lifecycle assessment of representative garments
Relevance Score: Medium - developed country context but methodological insights applicable

A.2 Nigeria-Specific Literature

Study ID: NG001
Authors: Oyelaran-Oyeyinka, B.
Year: 2020
Title: Industrial development and technological capability: The Nigerian textile industry in historical perspective
Journal: Research Policy
Volume/Pages: 49(2), 310-325
Study Type: Historical Analysis
Geographic Focus: Nigeria (National)
Key Findings: Analysis of factors contributing to textile industry decline and revival attempts
Methodology: Historical institutional analysis with policy document review
Relevance Score: High - directly addresses Nigerian textile industry experience

Study ID: NG002
Authors: Ibrahim, H., & Suleiman, M.
Year: 2022
Title: The decline and fall of Kaduna textile mills: An industrial archaeology perspective
Journal: African Archaeological Review
Volume/Pages: 39(2), 245-267
Study Type: Case Study
Geographic Focus: Kaduna State, Nigeria
Key Findings: Detailed analysis of Kaduna textile industry infrastructure and decline
Methodology: Industrial archaeology with oral history interviews
Relevance Score: High - specific to Kaduna case analysis

Study ID: NG003
Authors: Bello, A. K., & Mohammed, A. S.
Year: 2021
Title: Institutional challenges in textile industry revitalization: Evidence from northern Nigeria
Journal: Development Policy Review
Volume/Pages: 39(4), 532-549
Study Type: Empirical Research
Geographic Focus: Northern Nigeria
Key Findings: Institutional capacity constraints affecting industry revitalization efforts

Methodology: Mixed methods with stakeholder interviews and policy analysis
Relevance Score: High - addresses institutional dimensions relevant to policy development

A.3 Circular Economy and Policy Literature

Study ID: CE001
Authors: Ellen MacArthur Foundation
Year: 2017
Title: A New Textiles Economy: Redesigning Fashion's Future
Publisher: Ellen MacArthur Foundation
Study Type: Policy Report
Geographic Focus: Global
Key Findings: Comprehensive framework for circular economy in textiles
Methodology: Multi-stakeholder consultation with quantitative analysis
Relevance Score: High - foundational circular economy framework

Study ID: CE002
Authors: UN Environment Programme
Year: 2021
Title: Sustainability and Circularity in the Textile Value Chain: A Global Roadmap
Publisher: UNEP Publications
Study Type: Policy Report
Geographic Focus: Global
Key Findings: Policy recommendations for textile sustainability transition
Methodology: Expert consultation with literature review
Relevance Score: High - international policy framework relevant to national implementation

Study ID: CE003
Authors: European Environment Agency
Year: 2024
Title: Textiles and the Environment: The Role of Design in Europe's Circular Economy Action Plan
Publisher: EEA Publications
Study Type: Policy Analysis
Geographic Focus: European Union
Key Findings: Assessment of EU textile circular economy policy effectiveness
Methodology: Policy evaluation with stakeholder assessment
Relevance Score: Medium - policy lessons transferable to other contexts

A.4 Waste Management Literature

Study ID: WM001
Authors: Ogundimu, O., Ajibade, F. O., & Oke, A.
Year: 2021
Title: Solid waste management in Nigeria: Problems, prospects and policies

Journal: Waste Management Research
Volume/Pages: 39(8), 1046-1058
Study Type: Review Article
Geographic Focus: Nigeria (National)
Key Findings: Systematic analysis of waste management challenges and opportunities
Methodology: Literature review with policy analysis
Relevance Score: High - directly addresses Nigerian waste management context

Study ID: WM002
Authors: World Bank
Year: 2022
Title: What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050
Publisher: World Bank Publications
Study Type: Statistical Report
Geographic Focus: Global with country-specific data
Key Findings: Waste generation projections and management capacity analysis
Methodology: Statistical analysis with projection modeling
Relevance Score: Medium - provides global context and Nigerian data

A.5 Industry and Economic Development Literature

Study ID: ED001
Authors: African Development Bank
Year: 2019
Title: Textile Industry Development in Africa: Opportunities and Challenges
Publisher: AfDB Publications
Study Type: Economic Analysis
Geographic Focus: Sub-Saharan Africa
Key Findings: Regional analysis of textile industry development potential
Methodology: Economic analysis with stakeholder consultation
Relevance Score: High - regional context directly relevant to Nigeria

Study ID: ED002
Authors: Commonwealth Secretariat
Year: 2024
Title: Africa's Fashion Economy: Opportunities for Sustainable Growth
Publisher: Commonwealth Publications
Study Type: Economic Report
Geographic Focus: Commonwealth Africa
Key Findings: Fashion economy contribution to economic development
Methodology: Economic analysis with case studies
Relevance Score: High - includes Nigeria-specific analysis

A.6 Environmental and Health Impact Literature

Study ID: EH001
Authors: Amusan, L., Saka, L., & Omoju, O.
Year: 2020
Title: Environmental implications of textile waste management in Nigeria: A systematic review
Journal: Journal of Cleaner Production
Volume/Pages: 267, 121445
Study Type: Systematic Review
Geographic Focus: Nigeria
Key Findings: Environmental impacts of current textile waste management practices
Methodology: Systematic literature review with environmental impact synthesis
Relevance Score: High - directly addresses Nigerian environmental context

Study ID: EH002
Authors: Geyer, R., Jambeck, J. R., & Law, K. L.
Year: 2017
Title: Production, use, and fate of all plastics ever made
Journal: Science Advances
Volume/Pages: 3(7), e1700782
Study Type: Empirical Research
Geographic Focus: Global
Key Findings: Quantitative analysis of global plastic and synthetic material flows
Methodology: Material flow analysis
Relevance Score: Medium - provides context for synthetic textile waste issues

A.7 Policy and Governance Literature

Study ID: PG001
Authors: International Labour Organization
Year: 2023
Title: Decent Work in the Circular Economy: Opportunities and Challenges for Africa
Publisher: ILO Publications
Study Type: Policy Report
Geographic Focus: Sub-Saharan Africa
Key Findings: Employment implications of circular economy transition
Methodology: Policy analysis with stakeholder consultation
Relevance Score: High - addresses social dimensions of circular economy policy

Study ID: PG002
Authors: Organisation for Economic Co-operation and Development
Year: 2022
Title: Global Plastics Outlook: Policy Scenarios to 2060
Publisher: OECD Publishing
Study Type: Policy Analysis

Geographic Focus: OECD and major emerging economies
Key Findings: Policy scenario analysis for materials management
Methodology: Scenario analysis with quantitative modeling
Relevance Score: Medium - policy methodology relevant to textile materials management