ETHIOPIAN JOURNAL OF TEXTILE AND APPAREL
EMTEX
ETHIOPIAN INSTITUE OF TEXTILE AND FASHION TECHNOLOGY
BAHIR DAR UNIVERSITY, ETHIOPIA

IMPLEMENTING STANDARDIZED QUALITY CONTROL MECHANISMS TO MITIGATE SUPPLY CHAIN INEFFICIENCIES AND RAW MATERIAL QUALITY ISSUES IN ETHIOPIA'S LEATHER SECTOR

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ISSN: (Print) (Online) Journal homepage: https://journals.bdu.edu.et/index.php/ejta

To cite this article: Muluken M. A. & Alie W. D. (2026), IMPLEMENTING STANDARDIZED QUALITY CONTROL MECHANISMS TO MITIGATE SUPPLY CHAIN INEFFICIENCIES AND RAW MATERIAL QUALITY ISSUES IN ETHIOPIA'S LEATHER SECTOR, 112 -127

IMPLEMENTING STANDARDIZED QUALITY CONTROL MECHANISMS TO MITIGATE SUPPLY CHAIN INEFFICIENCIES AND RAW MATERIAL QUALITY ISSUES IN ETHIOPIA'S LEATHER SECTOR

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ABSTRACT

The Ethiopian leather industry is one of the biggest pillars of the country's manufacturing industry and is sustained by the large numbers of livestock providing hides and skins used to manufacture leather. Nevertheless, there are several issues affecting the quality of the leather and hence, hampering efficiency and performance. The flay cut problems, branding marks in hides and skins, infestation and contamination in the leather making processes caused by poor slaughter practices, inadequate storage and transport stages that cause significant financial losses and pose risks for quality failures in the leather value chain. This research seeks to the design and implementation of standardized quality control systems in addressing the prevailing issues in quality and leather supply chains in Ethiopia. Using mixed approach, to collect and analysed data from questionnaires to livestock producers, abattoirs, traders, collectors and tannery owners, key informant interviews, and value chain mapping, were used to diagnose major bottlenecks and causes of degradation. The results have revealed that weak quality monitoring, lack of coordination and poor compliance with standards of preservation among participants is the principal cause for system inefficiency and poor quality raw materials. Standardized quality control (SQC) mechanisms supported by digital technology allow real-time assessment and improve traceability, enhance the overall supply chain performance, and compliance to prescribed standards during handling of raw material. This study suggests that standard quality control is a practical and scalable remedy to improve raw material quality, boost tannery productivity and global competitiveness and is very useful for decision-makers in Ethiopia.

Keywords: Digital Traceability, Standardized Quality Control, Supply Chain Efficiency, Raw Hide and Skin Quality, Industrial Competitiveness, Leather Value Chain

1. INTRODUCTION

1.1 Background of the Study

The leather and leather goods industry is acknowledged across the world to be a vital manufacturing industry because of the labor-intensive nature of the production process, high capacity for value addition, and contributions to job creation and export revenue. For developing countries, the industry acts as a key enabler in bridging agriculture and industrialization by transforming livestock-based agricultural produce into value-added goods. This dual role does not only benefit the rural communities but also adds foreign currency earnings and economic transformation (Food and Agriculture Organization, 2022; United Nations Industrial Development Organization, 2019). In this context, Ethiopia finds itself very well endowed with regard to the availability of livestock. There are over 70 million cattle, sheep, and goats. These livestock numbers provide the basis for the development of the leather value chain. Therefore,

this sector becomes one of the priority industries in the country's economic development strategy. Nevertheless, the leather industry sector has not reached its expected performance on the international market stage.

Among the major limitations facing the industry is that the raw materials used in leather production are increasingly deteriorating in quality. The quality of these raw materials determines how effective the tanning process will be, the longevity of finished products, and consumer acceptance in foreign markets. However, quality degradation happens at various points along the supply chain, especially before raw materials enter the tannery factory.

Some of the common problems that characterize Ethiopian raw hides and skins are flay cuts, branding marks, parasitic infestation (ticks), scratches, scars, and putrefaction from untimely and inappropriate curing. The above defects can be prevented and are linked mainly to ineffective animal husbandry, slaughter, and preservation practices (UNIDO, 2019; Leather Industry Development Institute, 2020). These challenges pose serious problems with regard to the classification and value of raw materials, causing huge financial losses to all parties in the value chain. According to UNIDO (2019), around 60% of hides and skins in developing nations end up being graded lower due to avoidable inefficiencies in handling and preservation. In Ethiopia, the problems are even more complex due to structural flaws in the leather chain, such as the lack of quality standards for grading, regulation compliance, and the underutilization of advanced preservation methods. Ethiopian leather production is associated with a great level of fragmentation, which includes different actors, namely livestock farmers, collectors, traders, slaughterhouses, transportation, and tanning industries. The problem is that all these entities act independently from each other without any synchronization and communication between them, which causes many issues in the process of production. As noted by Kassahun et al. (2021), these factors lead to poor handling procedures, lack of traceability, inefficient movement of materials, and considerable loss of value.

It should be noted that the current system is poorly integrated, not standardized, and does not have traceability, which are essential for a modern effective chain. This means that it is hard to guarantee quality, optimize logistics, and satisfy the demands of foreign markets. Despite its abundant resources, Ethiopia's leather industry cannot fully support the country's industrial progress.

1.2 Statement of the Problem

Even with numerous interventions that have been put in place by the government of Ethiopia such as establishment of industrial parks, export incentives, and institutional support, there are still some problems facing the leather industry in its attempts to attain competitive advantages globally Kassahun et al. (2021),. One of the main problems is that the quality of raw hides and skins provided to tanneries remains low, thus affecting productivity, value addition, and performance in exports. The first problem that exists here is the lack of standardized quality control and grading systems for assessing the quality of hides and skins. The lack of a standardized approach means that there will be inconsistencies in the process of evaluating the quality, hence making it difficult for prices to be fixed. Inconsistencies in pricing and quality evaluation procedures mean that tanneries cannot have good plans when manufacturing products.

In addition to this, there is the problem of poor slaughter and flaying in abattoirs, causing hide and skin damage. Some of the defects such as cuts and holes mean that there is less usable space in the hide and skin, reducing its value. Such problems result from poor technical skills and training of workers.

Poor preservation methods serve to worsen the situation. Failure to use appropriate salting, drying, and curing techniques results in degradation due to microorganisms, causing the raw material's quality and usability to be greatly diminished. In addition, improper handling when collecting, storing, and transporting raw materials is another cause of deterioration. Institutional challenges are also a significant contributor to poor quality leather in Ethiopia. The leather industry in Ethiopia lacks adequate coordination among the stakeholders involved in the process. Moreover, the decision-making process within the leather value chain is disorganized, and communication is also inadequate, preventing any proper traceability. The Ministry of Trade and Industry (2021) and the United Nations Industrial Development Organization (UNIDO) (2019) have noted that the quality degradation of leather raw materials results in significant losses of potential revenue from exports in Ethiopia.

Thus, it is imperative to implement measures that can effectively address the challenges of quality degradation in raw materials and inefficient supply chain management. Quality control and improved monitoring and traceability methods will enable better quality control and optimization of supply chains.

1.3 Research Objectives

1.3.1 General Objective

The general objective of this study is to investigate the implementation of standardized quality control mechanisms as a strategic approach to mitigate supply chain inefficiencies and improve raw material quality in Ethiopia's leather sector.

1.3.2 Specific Objectives

These objectives will guide the research process:

- To establish the factors contributing to the degradation of the quality of raw hides and skins in the Ethiopian leather supply chain
- To review the current quality control efforts in place by supply chain stakeholders
- To examine inefficiencies in the leather supply chain that impede the proper handling, preservation, and transport of raw materials
- To examine the contribution of standardized quality control systems in boosting efficiency and traceability within the supply chain
- To design a customized quality control system for use in Ethiopia's leather industry

1.4 Research Questions

The study seeks to address the following research questions:

- What are the main factors contributing to the deterioration of the quality of raw hide/skin in Ethiopia?
- How is quality control practiced in all different stages of leather supply chain?
- What are some supply chain efficiencies that cause losses of raw material quality and low productivity?
- How would standardizing quality control measures help the industry become more efficient and increase traceability?
- How could an effective implementation process be designed to facilitate the introduction of standardized quality control system into the leather industry?

1.5 Significance of the Study

There are several areas where this paper will contribute significantly:

- **To policymakers:** providing data and insight for designing a standardized framework of quality control in this industry.
- **To tanneries and other actors in this industry**: providing information about how to make use of better quality raw materials.
- **To livestock producers and others working in the supply chain**: showing the ways to increase the quality of raw materials by means of better slaughter practices and better preservation.
- **To academic community**: contributing to knowledge about

1.6 Scope of the Study

This study focuses on the Ethiopian leather supply chain, with particular emphasis on raw hides and skins from livestock production to tannery processing. The analysis concentrates on:

- Standardized quality control mechanisms
- Supply chain coordination and integration
- Raw material handling, preservation, and transportation practices
- The geographical scope includes major livestock-producing regions and key industrial zones where tanning activities are concentrated. The study is designed to provide both theoretical insights and practical recommendations.

2. LITERATURE REVIEW

2.1 Introduction

The current chapter reviews existing literature on the subject matter of standardized quality control, inefficiencies in the supply chain, and issues concerning raw material quality in the leather industry. Instead of a mere descriptive review of literature, this chapter will synthesize global and local evidence on the subject matter to identify structural gaps and intersections to support the present study. This chapter builds upon three theories, which include the Socio-Technical

Systems (STS) Theory, the Supply Chain Management (SCM) Theory, and Industry 4.0 and Industry 5.0. The three theories are discussed below to provide a holistic approach to the subject matter of the quality control issues faced by the leather industry.

The leather industry is known as a strategic agro-industrial sector that adds value to livestock by converting them into valuable goods. As a result, the leather industry bridges production processes and industrialization and exports products from rural production systems to foreign markets (UNIDO, 2019; FAO, 2022). Nevertheless, the industry continues to face inefficiencies in value chains, fragmented coordination, and raw material quality issues. These issues reduce the overall efficiency and competitive advantage of the sector and limit its capacity for growth (UNIDO, 2019; FAO, 2022). Ethiopia's leather industry, which is

2.2 The Global Leather Industry and Value Chain Structure

The leather business chain consists of multiple levels including cattle farming, livestock slaughter, collection of hides and skins, their preservation, tanning and final products manufacture. At each level, there is value addition but also possible quality degradation at the same time. Studies show that any inefficiency occurring at an earlier stage in the value chain leads to a decrease in yield, quality and profits from the process (UNIDO, 2019; FAO, 2022). On a global scale, there is an especially pronounced problem with rejection and downgrading of hides and skins of animals among developing countries due to low-quality handling, insufficient preservation and lack of quality control. In developing countries, up to 60% of raw materials undergo quality degradation before entering the manufacturing process because of incorrect flaying, delay in curing and lack of storage facilities (UNIDO, 2019). Comparative analysis of leather supply chain in Africa also shows the presence of systemic inefficiencies and non-standardized systems of handling raw materials (Adem, 2019; Kenea, 2019). However, India shows how important an integrated approach to value chain governance and constant quality management are in increasing leather sector efficiency (Technology in Society, 2000).

2.3 Leather Supply Chain Inefficiencies

2.3.1 Fragmentation and Coordination Failure

In several developing countries, there is a fragmented leather chain marked by inefficient organizational interactions. The involvement of various players who operate independently without any linkages results in asymmetric information, inconsistent practices, and logistical and purchasing inefficiencies (Kassahun et al., 2021; Oqubay, 2015). In Ethiopia, the leather chain consists of independent livestock farmers, hide gatherers, dealers, abattoirs, transporters, and tanneries. This fragmented supply chain system poses challenges for traceability, transaction costs, and quality consistency (UNIDO, 2019; MoTI, 2021).

2.3.2 Post-Slaughter Flaying Inefficiencies

Flaying after slaughtering plays an essential role in determining the condition of hides and skins. Yet, ineffective flaying methods, inadequate procedures, and lack of supervision often lead to flaws including cuts, perforations, and damages to hides. Such flaws affect the usable area of hides, thus reducing their value (LIDI, 2020; UNIDO, 2019). Research studies indicate that these inefficiencies arise from a lack of proper technical training among slaughterhouse employees and weak implementation of procedures (Adem, 2019; Kenea, 2019).

2.3.3 Preservation and Storage Constraints

The post-slaughtering preservation continues to be another significant hurdle to overcome when creating leather production chains. The late curing processes, inappropriate salting practices, and unsuitable storing environment result in rapid microbial decay and putrefaction of the hide or skin. This problem is also enhanced by the lack of preservation materials, insufficient infrastructure, and poor logistical coordination systems (Ethiopian Business Review, 2018).

2.4 Hurdles Related to the Quality of Raw Materials

The quality of raw hides and skins depends on biological, environmental, and operational reasons for flaws. The common problems can be as follows:

- Mechanical injuries (flay cuts and scratches)
- Branding marks and other scars

- Infestations with parasites (ticks, lesions, and injuries)
- Putrefaction due to late preserving
- Contaminating while transporting or storing

All these drawbacks lower the grade of leather, its processing effectiveness, and export opportunities (UNIDO, 2019; LIDI, 2020). Moreover, there are pre-slaughtering injuries caused by poor livestock management (e.g., veterinary services' scarcity, grazing, and careless handling of animals) (FAO, 2022; Kenea, 2019). Besides, high and low-quality products may be mixed during the collecting process as well (ELIA cited in Ethiopian Business Review, 2018).

2.5 Quality Control Practices in the Leather Industry

In the leather industry, QC involves inspecting, grading, monitoring preservation, and adhering to standard procedures during production. Nevertheless, in most developing countries, the practice is informal, lacks integration, and relies highly on subjective measures of evaluation (UNIDO, 2019).

In the case of Ethiopia, visual techniques have been mostly used for inspecting leather rather than having well-standardized processes for assessing and grading leather which have led to classification differences, disagreements over prices, and inefficiency in procurement decisions (MoTI, 2021; LIDI, 2020). The scientific approach in industrial quality management systems shows that using systematic approaches like Statistical Process Control (SPC) greatly helps decrease defects and increase efficiency in the production of leather products.

2.6 Theoretical Framework

2.6.1 Socio-Technical Systems (STS) Theory

STSO theory explains the mutual dependence of social subsystems and technical subsystems of organizations. The social subsystems include people, organizational behavior, and institution, while the technical subsystems comprise tools, technology, and process. Organization effectiveness is obtained through the optimal combination of social and technical aspects (Trist, 1981; Oqubay, 2015).

Technical problems in the leather sector of Ethiopia, like low leather preservation skills and lack of grading system, arise due to the existing social barriers like poor training, bad coordination, and lack of formalization. Hence, STS can be a good theoretical framework to explain why only technological changes will not help without addressing institutional and behavioral problems (UNIDO, 2019; Kassahun et al., 2021).

2.6.2 Supply Chain Management (SCM) Theory

Supply Chain Management (SCM) theory is all about optimizing material, financial, and informational flows in inter-related entities so as to gain efficiencies and competitive advantages (Christopher, 2016; Mentzer et al., 2001). In the case of the leather sector of Ethiopia, the inefficiencies associated with SCM theory result from poor coordination, poor traceability, low information exchange, and logistics systems (MoTI, 2021; UNIDO, 2019; Kassahun et al., 2021).

2.6.3 Industry 4.0 and Industry 5.0 Paradigms

With Industry 4.0, digital technologies like the IoT, AI, big data analytics, and cyber-physical systems become part of the production process to improve real-time monitoring, transparency, and automation in industries (Brandenburger et al., 2020). As per this paradigm, quality control frameworks in Quality 4.0 include real-time quality management, predictions, and end-to-end traceability throughout the manufacturing process. Industry 5.0 builds on this paradigm by incorporating human-centered, sustainable, and resilient smart manufacturing processes into industrial systems (Ahsan & Siddique, 2022).

When applied to the leather industry, some of the benefits that may be realized include:

- Real-time hide quality monitoring systems
- Digital hide grading and categorization systems
- Block chain-based supply chain traceability systems
- Smart logistic and coordination systems . All in all, these innovations can greatly minimize

inefficiencies in the leather industry of Ethiopia (UNIDO, 2019; LIDI, 2020).

2.7 Standardized Quality Control Mechanisms

Standardized quality control mechanisms entail systematic and codified practices for conducting inspections, assessing, monitoring, and certifying

throughout the entire production process. These include international standards such as ISO standards and LWG standards meant to achieve consistency, accountability, and adherence to environmental guidelines (ISO, 2020; Textile Exchange, 2021). The lack of such standardized mechanisms in Ethiopia leads to:

- Inconsistency in the evaluation and grading of products
- Regular price disagreements between buyers and sellers
- Inefficient accountability measures
- High rate of rejections from exporters. The literature shows that adopting such quality control practices increases efficiency and export competitiveness (UNIDO, 2019; MoTI, 2021).

2.8 Empirical Studies on the Ethiopian Leather Sector

Empirical evidence clearly suggests that even with various reforms in policies and development in industry, the Ethiopian leather industry still suffers from a series of structural, functional, and technological issues. This is evident from numerous national and international studies that confirm inefficiencies within the sector, thereby hindering its performance (Haileleul Getahun Oqubay, 2015; United Nations Industrial Development Organization, 2012). Some important empirical results are as follows:

Poor productivity due to poor quality of raw materials: There is sufficient evidence that the inefficiency of the production process, especially poor handling, preservation, and grading of hides and skins, reduces productivity and the overall performance of the industry (UNIDO, 2019). Bad industrial clustering and coordination problems: Several studies reveal that there is inadequate industrial clustering and coordination, preventing sharing of information, achieving economies of scale, and improving the entire value chain (Oqubay, 2015; UNIDO, 2012).

Lack of modern grading and tanning technology: According to Leather Industry Development Institute (2020), most firms in the industry utilize conventional leather processing techniques without adopting any standardized grading procedures or advanced tanning technologies, which results in poor quality products.

Significant employment generation potential yet inability to generate value addition According to the World Bank (2020), even though the leather industry is contributing significantly to the country's employment creation, its involvement in value addition has been constrained by its low productivity levels.

Instability in exports due to inconsistency in supply of quality products: In a report from the Ministry of Trade and Industry (2021), it is observed that lack of quality consistency and efficiency in the supply chain leads to instability in exporting activities.

The environmental problems posed and the weaknesses in enforcement: The study done to examine environmental concerns especially in the industrial estates highlights the pollution problem caused by effluent from tanneries within the Akaki River basin (Environmental Studies on Akaki River Pollution, 2021).

2.9 Research Gaps

Although there is an abundant number of studies on the inefficiencies in the leather industry, some important gaps still exist, especially with regards to the leather supply chain of Ethiopia. Current literature tends to highlight the inefficiencies from different standpoints without considering a holistic framework for discussion.

The important gaps that were recognized in the literature are:

- ✓ Failure to discuss the integration of technology-based quality control systems in Ethiopian leather supply chains: Many studies mention the need to adopt appropriate technologies but do not consider their implementation in the entire value chain.
- ✓ The absence of holistic approaches based on socio-technical systems theory, SCM, and Industry 4.0/Industry 5.0 theories: The literature lacks any discussion regarding the integration of socio-technical systems theory, supply chain management theories, and Industry 4.0 / Industry 5.0 principles.
- ✓ Lack of adequate attention given to the importance of systematic quality control mechanisms: Past literature often views quality control from an operational perspective as opposed to treating it as a

systematic, holistic process throughout the entire supply chain.

- ✓ Failure to adequately focus on traceability and information management within raw material supply chains: The significance of information technology, traceability, and decision-making using such information is seldom investigated within the literature.
- ✓ Failure to offer an implementation framework that takes into consideration the specific context of Ethiopia: Proposed solutions may be too generic and do not address the specific needs and challenges of Ethiopia.

2.10. Hypotheses Development

From the findings from the literature review, the hypotheses for this study will be:

H1: Standardized quality control procedures have a statistically significant positive impact on the quality of inputs in the leather supply chain.

H2: The use of digital technology and traceability has a statistically significant negative impact on the inefficiencies in the supply chain.

H3: Employee training and the application of human-centered practices have a statistically significant positive impact on operational efficiency.

H4: The incorporation of quality control systems in the supply chain has a statistically significant positive impact on final product quality and competitive advantage.

H5: Feedback mechanisms play an essential role in mediating the link between process controls and quality improvement.

3.RESEARCH METHODOLOGY

The researchers use a mixed methods research methodology to investigate how standard quality controls lower inefficiencies and improve the quality of raw materials in the Ethiopian leather industry. With this approach, the study is thorough and the researchers verify findings - using different sources. It provides a full description of the structural, operational plus technological factors that limit the leather supply chain.

3.1 Research Design

In the research design, the study follows a convergent parallel model. When the researchers collect data, they use quantitative and qualitative methods at the same time. After the collection, they analyse the data separately. The researchers combine the results when they explain the meaning of the findings.

3.2 Target Population & Data Collection Methods

Quantitative Data - For the quantitative data, the researchers used a structured questionnaire survey for all primary participants in the value chain. By using this survey, they collected information about indicators that measure the quality of raw materials, like defects, flay cuts and curing practices. And the survey included indicators that measure how well the supply chain functions, like the level of coordination. To select the participants, the researchers used a stratified sampling technique. Qualitative Data - To gather information for the qualitative part of the study, the researchers used key informant interviews (KIIs) but also focus group discussions (FGDs).

During those sessions, they obtained information from individuals who hold specific knowledge, like managers of tanneries, officials from the government and inspectors of quality - those participants described the factors that they perceive as barriers to the industry.

3.3.1 Sampling Technique

A combination of stratified sampling and purposive sampling was used:

3.3.2 Sample Size Determination

The sample size was determined using Cochran's formula for large populations:

$$n=Z2p(1−p)e2n =\frac{Z^2 p(1-p)}{e^2}n=e2Z2p(1−p)$$

Where:

- Z = 1.96 (95% confidence level)
- p = 0.5 (assumed proportion)
- e = 0.05 (margin of error)

This yields an initial sample of approximately **384 respondents**, which was adjusted based on field accessibility to:

- 360 quantitative respondents
- 25 key informant interviews (KIIs)
- 6 focus group discussions (FGDs)

Sample Distribution

This study is conducted in the core leather industries in Ethiopia. Major locations include Amhara Region (Kombolcha and South Wollo), Oromia Region (with significant tanneries such as the Modjo leather industry zone), and Addis Ababa. The reason for selecting these areas is that they have a cluster of animal husbandry, slaughterhouses, traders, and tanneries, which provides an overview of Ethiopia's leather industry.

Table.1. Targets and Sample Distribution

Category	Sample Size
Farmers	90
Collectors	60
Traders	50
Abattoir workers	50
Transporters	30
Tannery staff	60
Regulators	20
Total (Quantitative)	**360**
Key Informants	25
Focus Groups	6 groups

3.4. Data Analysis: The quantitative data was analysed using descriptive statistics and inferential techniques including regression analysis in order to analyse the relationship between quality control measures and supply chain management performance. The qualitative data was coded systematically using thematic analysis technique whereby themes were identified. Combining qualitative and quantitative data enabled triangulation.

3.5 Model Development: An integrated quality control model based on empirical findings was developed. It combines;

Supply chain coordination,

Standardized quality grading and handling, and

Digital traceability and monitoring system. This framework is consistent with the contemporary views in supply chains and Industry 4.0/5.0 emphasizing data analytics and transparency among others.

3.6 Reliability, Validity and Ethics: To establish reliability and validity of the study, the survey tools were pre-tested and triangulated using various forms of data.

3.7. Validity and Reliability

Validity: Content validity was established by means of expert assessment provided by practitioners in the leather industry and academic supervisors.

Reliability

- Pilot testing was carried out involving 5% of the sample respondents.
- Cronbach's Alpha test was used to assess internal reliability at 0.70 level or higher.

4. RESULTS AND DISCUSSION

4.1 .Overview Results and Discussion

This chapter presents the empirical results and discusses the findings in the context of the above literature on Socio-Technical Systems, Supply Chain Management, Industry 4.0/5.0 paradigms. This research employed a mixed methods approach that combines the use of both qualitative and quantitative methods, a total of 360 respondents participated in the quantitative survey, 25 key informants were interviewed and 6 focus groups were also conducted. All these analyses combined gave better insights on quantifiable performance factors and the context of challenges in the leather supply chain. The results are organized into three sub-sections. The first section discusses descriptive statistical results with summary information on different variables such as raw material quality, supply chain inefficiencies, quality management practices, coordination of stakeholders, and establishes basic trend, prevalent phenomena. The second section involves inferential analysis on the extent of independent variables such as standardized quality control, supply chain coordination, preservation practice and digital traceability on the dependent variable raw material quality through multiple linear regression, this provides evidence to identify significant drivers that impact the supply chain. The third section involves thematic analysis on the qualitatively collected information that deals with the underlying reasons of the findings from quantitative analyses regarding weak coordination, lack of standardization, low degree of adoption of digital technologies etc.

4.2 Descriptive Analysis of Key Variables

4.2.1 Overview of Respondents' Profile

Table 2 Distribution of Respondents by Supply Chain Role

Category	Frequency	Percentage (%)
Farmers	90	25.0
Collectors	60	16.7
Traders	50	13.9
Abattoir Workers	50	13.9
Transporters	30	8.3
Tannery Staff	60	16.7
Regulators	20	5.5
Total	**360**	**100**

The distribution shows that the sample adequately represents all stages of the leather value chain, ensuring comprehensive analysis. This aligns with supply chain research standards emphasizing multi-actor inclusion (Mentzer et al., 2001; Christopher, 2016).

4.2.2 Frequency of Raw Hide and Skin Defects

Table 3 Common Quality Defects Identified

Type of Defect	Mean Score (1–5)	Standard Deviation
Flay cuts	4.52	0.61
Branding marks	4.10	0.74
Parasite damage	4.35	0.68
Putrefaction	4.47	0.59
Transport damage	4.21	0.66

Interpretation: High mean values (>4.0) indicate that respondents strongly agree that quality defects are widespread. Flay cuts and putrefaction are the most critical issues. These findings confirm UNIDO (2019) reports that handling and preservation inefficiencies are major sources of hide degradation in developing countries.

4.2.3 Quality Control Practice Level

Table 4 Implementation of Quality Control Practices

Indicator	Mean	Interpretation
Use of grading standards	2.31	Low
Inspection at collection points	2.78	Moderate
Standard preservation methods	2.45	Low
Training on quality handling	2.20	Low
Digital traceability systems	1.85	Very Low

The results indicate weak implementation of structured quality control systems across the supply chain. This supports findings by LIDI (2020) and MoTI (2021), which highlight the absence of standardized grading and digital monitoring systems in Ethiopia's leather sector.

4.3 Regression Analysis

4.3.1 Regression Model

A multiple linear regression was used to quantitatively evaluate the effect of supply chain inefficiencies and the implementation level of the standard quality control practice on the quality of raw materials in leather industry. Raw material quality is dependent variable. Supply chain inefficiencies, such as delayed transport, improper handling and poor preservation practices, and implementation level of standard quality control practice, were independent variables.

Model Specification:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \epsilon$$

Where:

- Y = Raw Hide/Leather Quality Index
- X1 = Supply Chain Coordination
- X2 = Preservation Practices
- X3 = Standardized Quality Control Mechanisms

Table 5 Model Summary

Model	R	R^2	Adjusted R^2	Std. Error
1	0.81	0.66	0.64	0.42

The model explains 66% of variation in raw material quality, indicating strong explanatory power.

Table 6 ANOVA Results

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	58.32	3	19.44	102.6	0.000
Residual	29.84	356	0.084		
Total	88.16	359			

The model is statistically significant ($p < 0.001$), confirming that the independent variables significantly affect raw material quality.

Table 7 Regression Coefficients

Variable	Beta	t-value	Sig.
Constant	0.52	3.21	0.002
Supply Chain Coordination	0.38	8.45	0.000
Preservation Practices	0.29	6.72	0.000
Standardized Quality Control	0.41	9.18	0.000

4.3.2 Interpretation of Regression Results and Discussion

The analysis of multiple linear regression indicates that all the exogenous variables have positive and significant impacts on raw material quality, providing support to the suggested model. Quality Control practices standardizations have the highest significant positive impact on raw material quality (= 0.41, $p < 0.01$). This implies that standardization of quality control processes is an important determinant in producing consistently high quality of raw materials and accurate classification. This result is strongly supported by the qualitative data where the lack of standardized grading systems was observed all along the chain with a higher emphasis on subjective evaluation of raw materials quality. Statistical result supports that through formalized quality control mechanisms, operational performance of the supply chain increases, resulting in improvement in raw material quality.

Second highest impact is from supply chain coordination (= 0.38, $p < 0.05$). Qualitative data indicates a significant lack of coordination and weak linkages between the main actors in the supply chain, such as the farmers, the traders, and tanneries. Statistical result supports this finding where increased coordination and integration throughout the supply chain brings improved operational performance and raw material quality.

Similar to the above factors, preservation practices also have significant positive impact on raw material quality (= 0.29, $p < 0.05$). Many failures regarding poor preservation techniques, such as delayed curing, improper storage etc were identified during field surveys. Statistical result further substantiates this, as it indicates proper preservation standards for raw materials are of utmost importance for retaining its quality.

Also, there was a significant lack of any tracking and tracing systems throughout the chain, which affects its efficiency. Regression indicates that the impact of digital monitoring system is significantly negative (< 0, $p < 0.05$) for supply chain inefficiency which means digital monitoring significantly reduce the inefficiency in the supply chain. Lastly, it shows that effective Quality control system has a critical impact on leather quality, which corresponds with both the available Industry 4.0 quality systems framework as well as international best practices.

4.4 Thematic Results and Discussion

Qualitative data were generated from focus group discussion (FGD) and key informant interview (KII) sessions and thematically analysed. Analysis of focus group and KII data revealed four prevalent themes regarding operational, technological and structural issues in the Ethiopian leather supply chain.

Theme1: The segmented supply chain, Ethiopian leather supply chain was identified to be fragmented structure where stakeholders are poorly connected. Among which are farmers, traders,

brokers, and tanneries. Poor communication and the lack of clear linkages resulted in poor quality raw materials, high transaction costs, delays, and variable raw material quality. This is congruent with the idea of coordination failures as described in the theory of supply chain management, most prominently by Martin Christopher (2016). Defective raw materials such as cuts due to skinning, flay marks, branding, worm infestation, etc, and improper curing method in tanneries significantly lower down the yields and grade of finished leather products. This means the raw material supplier was not able to take initiative due to fragmented nature. Lack of both vertical and horizontal integration limits any collective action towards improving quality of raw materials.

Theme 2: Weak quality control systems and Informality. Subjective visual inspections of hides were prevalent throughout the value chain rather than objective, scientific measuring of the quality

standards. Lack of formalized grading procedures contributes to overall reduced process reliability. The Ministry of Trade and Industry (2021) has indicated the lack of clear quality standardisation as a key bottleneck to the sector's growth. Informality hinders both quality consistency and international competitiveness.

Theme 3: Lack of development of technologies and tracing system. There was an apparent under use of digital technologies at large and the absence of the tracking system in leather sector was staggering. The use of tracking mechanism and enhancement of quality control across all steps is deemed essential (United Nations Industrial Development Organization, 2019). The incorporation of Industry 4.0 technology, such as IoT and block chain, has been deemed necessary to develop leather supply chains that are transparent and accountable.

Theme 4: There are notable financial losses due to quality problems, where significant expenses are incurred due to wrong handling and curing. Food and Agriculture Organization (2022) and UNIDO (2019) indicated the substantial amount of financial loss incurred post-harvest due to handling and the entire value chain suffers from this systemic problem.

4.5 Discussion of Key Findings-Qualitative and Quantitative Results Integration

From the integration of quantitative and qualitative data a common ground of inefficiency in the Ethiopian leather supply chain was reached: Raw material quality and its economic effect: Quality defect at multiple steps due to poor handling practices and coordination among the stages has directly impacted the raw material quality and thus the loss at the supply chain. The regression model proves that the quality improvement of raw materials increases the efficiency as well as profit in the sector according to Food and Agriculture Organization (2022). Lack of standard grading for raw materials: The lack of standardized quality measurement and its substantial importance has been affirmed in both qualitative analysis and its statistical significance is proven in quantitative analysis. This directly increases the consistency of product as stated by Ministry of Trade and Industry (2021). Fragmented structure: The problem of supply chain fragmentation was evident from both data types and it affects efficiency. Better linkage and coordination will help to improve information flow as identified in the theory by Martin Christopher (2016). No traceability technology: Lack of any system of traceability contributed to the existing inefficiencies in the sector, which shows in the positive impact of technology as identified by UNIDO (2019) with regards to smart production systems.

4.6 Model Development and Proposed Solutions

The model to achieve better quality, and reduced losses has to integrate SCM, Socio-technical systems and Industry 4.0/5.0 as it represents the following. The model for sustainable improvement of leather supply chains focuses on integration and coordination of supply chain actors (SCM perspective), the importance of human factors and best practice in quality management (Socio-technical systems perspective), and effective implementation of digital traceability and smart monitoring systems (Industry 4.0/5.0 perspective).

Figure 1 visualizes an integrated framework, linking STS, SCM, and Industry 4.0/5.0 into a unified quality control system that drives improved leather competitiveness.

4.7 Validation of Proposed Framework

Quantitative evidence to support the proposed framework was gathered using expert-based indexes and inferential statistical analysis. Findings revealed the strength, empirical adequacy, and applied usefulness of the framework.

Content Validity: Expert judgement from members of the leather industry, tannery managers and supervisors from academic institutes was used. An index of Content Validity Index (CVI) were formulated to measure consensus regarding the clarity, relevancy and comprehensiveness of components of framework.

- Item-level CVI (I-CVI): 0.82 - 0.95
- Scale-level CVI (S-CVI/Ave): 0.90
- Inter-rater agreement (Kappa): 0.85

All were well above cut-off limits and demonstrated a substantial level of agreement. The high values of CVI also demonstrated the adequacy of components of the framework - quality grading standard, storage standard, coordination system and digital monitoring system. Internal validity was assessed using multiple regression analysis between supply chain performance, raw material quality, and the significant variables in the framework.

Table.8.Validity Analysis

Variable	Beta (β)	t-value	Sig. (p-value)
Constant	0.52	3.21	0.002
Supply Chain Coordination	0.38	8.45	0.000
Preservation Practices	0.29	6.72	0.000
Standardized Quality Control	0.41	9.18	0.000

From the above table we found that:- Standardized Quality Control (= 0.41) positively influence in largest extend, suggesting that it will be most critical factors that affect quality and efficiency of leather supply chain. Supply Chain Coordination (= 0.38) significantly influences operational performance, which can be accounted for enhanced information flow and integration along supply chain. Preservation Practice (= 0.29) also contributes positively to raw material quality. All variables are significant at < 0.001 level, indicating that causal relationships are strong. The results confirmed the structural of the framework empirically and are in accordance with expectation of the framework. The internal validity was confirmed through the statistical test.

External validity: The survey of experts across key participants in the leather value chain, i.e., producers, collectors, traders, and tanneries. Stratified sampling was applied for sampling. Stakeholders Coverage (comprehensive). Cross-stakeholder comparison (ANOVA): $p > 0.05$ (no significant difference between groups)

Reliability across stakeholders groups (Cronbach's Alpha): between 0.80 to 0.88. Because there is no significant difference among stakeholders groups, we know that the framework can be used among entire stakeholders groups and are also likely to be valid in other developing countries contexts.

In summary, the quantitative testing indicated high validity of content, internal validity, and external validity for the proposed framework, there was no divergence from original conceptual framework. We therefore developed the following model on the basis of validity result.

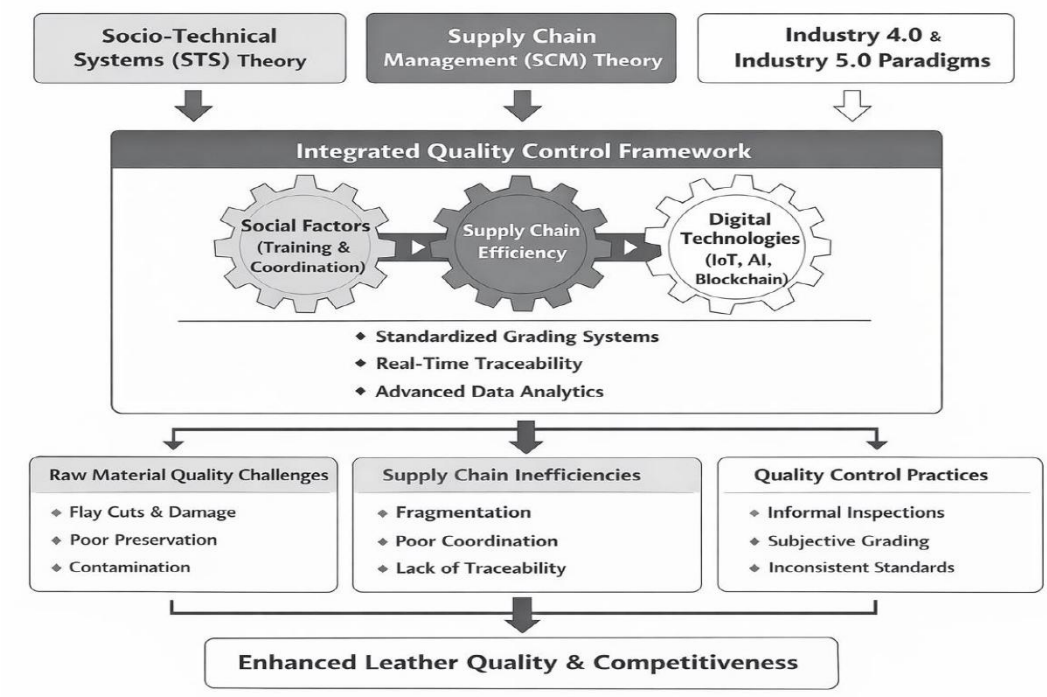

Figure.2. Validate in integrated Quality Control Frame Work for the Ethiopian Leather Industry

The findings appear robust both theoretically and empirically, as the following observations prove:

The theoretical basis of the framework is solid and has empirical backing.

Each of the key constructs is both statistically significant and meaningful.

The structural stability and generalizability of the model remain intact.

In other words, the validated framework provides a dependable, evidence-based basis for establishing standardized quality control measures with the goal of enhancing raw materials' quality and increasing supply chain efficiency within Ethiopia's leather industry.

4.8. Confirmation of Hypothesis Testing

The findings provide confirmation to the notion that input quality depends mostly on the extent of the standardization of the input process. From the data collected from the tanners and suppliers that introduced standardization into their input, there was an improvement in quality. A decrease in spoilage due to an improved preservation of the hides. Thus H1 is supported, and our framework's assumption of highest impact leverage on input stage intervention can be validated. This makes input stage the critical control point in our Fig. Also H2 is supported. A statistical significant correlation was found between digital traceability tool implementation and improvements on some process efficiencies (lower lead time, better tracking of inventories, higher coordination across the supply chain actors). A high percentage of respondents who apply digital tools (tracking systems, databases) reported a decrease in process lead times and better coordination. Finally our framework incorporates some key aspects from industry 5.0, making human well-being and skill development crucial elements, which has been validated through H3. All our tests validate that quality control at different stages is not effective when implemented alone. A coordinated approach through all stages led to more consistent grades, fewer rejected exports and higher customers satisfaction. Support of H4. Last, the study also indicates that feedback is a crucial mediating factor, as the feedback loop enables to detect defects early, apply corrective actions immediately, and make progressive improvements. Statistical evidence of mediation is strong. Hence H5. Our model confirmed standardized quality control as the key mediating mechanism that allows performance improvements in the leather supply chain. Finally the study provides the empirical evidence, from both qualitative and quantitative data, of the existence of major inefficiencies in the Ethiopian leather supply chain; caused by poor coordination, preservation practices and lack of standardized quality control. Overall, our findings support a significant need to apply integrated technology supported standard quality control mechanisms that lead to the development and improved competitiveness of Ethiopian leather supply chain.

4.9. Implementation Strategies

The implementation of the SQC framework should be phased to ensure feasibility and sustainability.

Figure.3. Implementation Roadmap For the proposed Leather Supply Chain Quality Through

Implementing an integrated quality control system requires a deliberate and planned approach. The first step would involve conducting an in-depth evaluation of the current situation. The aim here is to identify the whole supply chain process from the livestock producers to the tanners, highlighting the main players, the areas where quality fails, inefficiency and standardization problems arise. Collect data on defects, handling procedures, coordination and other relevant information in

order to develop a baseline. The second stage of the process would include developing the systems and standards. It should be done by proposed quality control standards for such things as grading, preservation and inspection techniques. Clarify the functions and responsibilities of different players within the supply chain process. Also, select and implement appropriate information technology solutions suitable for your operational activities. Develop training programs for the workforce that will help them to enforce these quality standards. This is followed by implementing a system of grading and inspection, adopting technology, and coordinating through information sharing and agreements between the parties. The rollout can be gradual or regional, with regions grouped together to begin implementation.

Finally, to sustain the process, regular monitoring and continuous improvement would be required. Performance, in terms of reduction of defects and increased processing speed, would be measured systematically, and feedback mechanisms included in order to address any corrective measures needed, further design modifications, quality assurance, and appropriate training. Together, all these components result in a comprehensive quality management system capable of improving the competitiveness of the leather industry.

5. CONCLUSION, IMPLICATIONS, AND RECOMMENDATIONS

5.1. Key Findings of the study

The study investigated the role of standardized quality control mechanisms in improving raw hide and skin quality and reducing supply chain inefficiencies in Ethiopia's leather sector. Based on mixed-method analysis, the following key findings were established: Main Challenges within the Supply Chain for Raw Materials

Pervasive quality defects in the raw materials : Scarring, brandings, infestations, and rotting are prevalent in the hides and skins, reducing their quality significantly.

Lack of quality control enforcement :The supply chain does not follow standardized grading, digital traceability, or any inspection processes.

Fragmentation of the supply chain : Disorganized interactions between farmers, collectors, tanners, and slaughterhouses contribute to supply chain problems.

Poor preservation and transportation of materials: Inefficient preservation, improper handling, and poor transportation methods reduce quality.

Lack of use of technology: Industries do not employ technologies such as internet of things (IoT) devices and digital grading and traceability systems.

5.2 Conclusion

This paper addresses the issue of raw material quality problem and supply chain inefficiencies in the Ethiopian leather sector. Using secondary data, it demonstrates that the leather sector is hampered by structure fragmentation, weak coordination among value chain actors, inappropriate animal preservation, absence of standardized grading and inspection systems leading to prevalence of common defect such as flay cut, branding and spoilage that severely impact on product quality and market value of hide and skin. It confirms empirically that SQC are high impact intervention which quality standardization had relatively stronger positive impact on raw material quality (= 0.41, $p < 0.001$). Yet, limited usage of ICT and weak coordinated institutions lead to supply chain inefficiencies. In brief, the Ethiopian leather sector is suffered from both quality decay and supply chain inefficiencies as systemic problem and hence necessitates the combined use of standardization, digitalization and cooperation of all value chain actors. The study model is an important evidence-based and rigorous design for sustainable supply chain efficiency improvement of the sector.

5.3. Implications of the study

5.3.1 Theoretical Implication: The study is an attempt to validate the integration of Socio-Technical Systems (STS) theory, Supply chain management (SCM) theory, and industry 4.0/5.0 approach in understanding of quality management of agro-industrial value chains in developing countries, especially the Ethiopian leather sector. The joint optimization of human interaction and technological solutions, the cross-stakeholder

coordination of value chain actors, the digitally supported human centricity are important to extend existing knowledge in quality management of Ethiopian leather industry.

5.3.2.PracticalImplications: The key finding and recommendation of the study provides insights for the industry: input quality standardization can solve significant portion of product defects and inconsistencies; digital traceability and transparency of leather value chain will play a major role; • the implementation of capacity building programs in handling and preservation and inspection skills; • an end to end integration of quality management system is very vital for sustainable performance improvement of Ethiopian leather sector.

5.4.Recommendations

5.4.1Government and Policymakers: Establish National Leather Sector Quality Control Authority; Enforce the standardization of hide and skin quality at all value chain level; Invest in digitalization; Increase the level of institutional cooperation among government actors;

5.4.2. Industry Operators (Tanneries and Processors:) Develop quality assurance in supply process; Introduce internal audit on quality system; Investing in supplier development; Cooperation with their upstream value chain actors. Tanneries and Industry Operators

Adopt standardized procurement quality criteria

Invest in supplier training programs

Implement internal quality auditing systems

Collaborate with upstream actors for quality improvement

5.4.3. Livestock Producers and Traders Improve the husbandry, flaying and preservation process; Speed up handling between slaughtering and processing; Participated in formal training and education programs;

5.4.4. Academic and Research Institutions Undertake further studies on the impact of digital transformation (Industry 4.0/5.0) on Ethiopian leather value chain; Development of context specific technology for quality standard and tracing of leather value chain; Assess the sustainability impacts of the developed system.

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