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Investigation of challenges for implementation of traceability system in tanning industry of Bangladesh.

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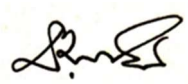
Abstract

Being one of the largest hide producers in the world, the leather industry of Bangladesh has huge potential to contribute to the economy of the country. But since the last decade this industry has been facing big challenges to comply with different international standards on environmental and social quality, more specifically LWG certification. One of the new challenges to achieve this certification would be to implement traceability system of raw materials in tanning industries. International organizations dealing with the compliance of leather sector are giving high emphasis on the traceability of the products, and in future it will be almost impossible to enter high value global leather market without traceability compliance as traceability has a major contribution in ensuring sustainable value chain. However, currently the status of the tanning industry in relation to traceability compliance is very underwhelming in Bangladesh. Only a very few industries have undergone the process, but no visible outcomes have been achieved yet. Therefore, this research has been conducted to investigate the underlying key challenges to introduce traceability system in tanning industry of Bangladesh. Both qualitative and quantitative methods have been used in this research. Secondary data have been collected through comprehensive desk review, and primary data have been collected through questionnaire survey, and key informants' interview (KII). To accomplish the research objective, supply chain of tannery has been drawn, qualitative risk analysis for noncompliance with traceability standard using bow-tie has been done, private cost-benefit analysis has been conducted for evaluating the investment appraisal for traceability, comparative study of available leather tracing technologies has been done, key stakeholders have been identified and analyzed, and finally factor analysis has been performed on 21 variables of the survey data to find out the underlying key challenges for implementation of traceability. The research result has revealed that there are four key factors such as 'lack of infrastructure', 'lack of financial support, 'lack of suitable technology', and 'lack of regulatory measures' which are collectively hindering the implementation of traceability in tanning industry of Bangladesh. To overcome these challenges, a multifaceted approach should be taken including construction of industrial and institutional infrastructure, increase of industry-academia relationships, financial incentives for the owners, and most importantly enforceable regulatory measures.

Preface

This report titled 'Investigation of challenges for Implementation of traceability system in tanning industry of Bangladesh' is written as the fulfillment of the requirement of 30 ECTS Master's thesis report for the 2-year master study program in Risk and Safety Management, Aalborg University, Esbjerg, Denmark. This study report has been carried out in the 4th semester of the study program (From September 2021 to June 2023). This thesis is intended for the persons and organizations who have interest on different compliance issues in the leather sector of Bangladesh, more specifically in the traceability compliance of hide in tannery industries of Bangladesh. The inspiration of this thesis was to find out the challenging factors for implementing traceability system in leather sector particularly tanneries of Bangladesh and way to overcome those challenges to have a sustainable leather value chain. Efforts have been made to use applicable tools in this thesis by utilizing the learning of all the previous semesters during this Master's course. This report consists of eight chapters and the outline of the report is presented on page viii. The reference style used in this report is APA.

Finally, we would like to express our gratitude to our supervisor, Dewan Ahsan and co-supervisor, Anders Schmidt Kristensen for their kind support and guidance throughout the project study. We would also like to thank the respondents of the survey, experts in leather sector of Bangladesh and BTA for their cooperation.



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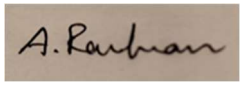

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Acronyms

BTA	Bangladesh Tanners' Association
BEI	Bangladesh Enterprise Institute
BSE	Bovine Spongiform Encephalopathy
BCR	Benefit-Cost Ratio
CSF	Critical Success Factor
CFA	Confirmatory Factor Analysis
COP27	The 27*th* Conference of the Parties of the United Nations Framework Convention on Climate Change
EU	European Union
EFA	Exploratory Factor Analysis
FAO	Food and Agriculture Organization
FA	Factor Analysis
FV	Future Value
ISO	International Standardization Organization
ILET	Institute of Leather Engineering and Technology
IRR	Internal Rate of Return
ICEC	Institute of Quality Certification for the Leather Sector
KII	Key Informant Interviews
KMO	Kaiser-Meyer-Olkin test
LWG	Leather Working Group
LIA	Leather Impact Accelerator
LFMEAB	Leather goods and Footwear Manufacturers & Exporters Association of Bangladesh
LCA	Life Cycles Assessment
NGO	Non-Government Organization
NPV	Net Present Value
PCA	Principal Component Analysis
PERT	Project Evaluation and Review Technique
PV	Present Value
RFID	Radio Frequency-Identification
RMG	Ready Made Garments
SPSS	Statistical Package for Social Sciences
TS	Traceability System

Report outline

Chapter one of this thesis report describes the research objectives based on the problem analysis along with the background of the thesis. It also covers the scope of this study.

Chapter two illustrates the literature review part which consists of the standard definition of traceability based on different literature, review of some research on traceability system including leather and other sector, generic benefits of having a traceability system in a supply chain and different aspects of traceability system in leather sector. This chapter also gives a brief idea of different certification of leather traceability system and their types according to LWG certification.

In the third chapter, the methodology used in this thesis has been described. In this chapter, data analysis procedure and survey procedure have been discussed along with how the questionnaire has been prepared and how the sites for data collection are being selected. Then the theories of the methods used in this paper have been discussed which includes bow-tie analysis, cost-benefit analysis, factor analysis and stakeholder analysis.

In the fourth chapter, results that have been obtained through review and analysis are described. This chapter comprises of the bow-tie analysis of non-compliance to traceability system, present status of hide supply chain, technologies used for leather traceability, private cost-benefit analysis, factor analysis, stakeholder analysis, and standard and legislation on traceability system.

In the fifth and sixth chapter, discussion and recommendations have been made based on the results of this study.

Finally, a summary of this study is given along with future research scope.

1.0 Introduction

For the last few decades, the whole world has been highly concerned about environmental responsibility, social responsibility, and traceability and transparency about consumer products for making sustainable business and economy throughout the globe. The leather industry is likewise very much focused on the same pathway. In recent years, traceability has become one of the key requirements for leather products to enter high value markets like Europe and America. The reason behind it is traceability ensures safety to the consumers by guaranteeing the origin of the products, optimizing logistics and management, and also complying with different laws and regulations in this regard which ultimately ensure a sustainable value chain in the leather industry (Thakur & Mehta, 2020). Beside these, international standards on traceability of leather products also consider animal welfare, deforestation and conversion of natural resources, biodiversity and climate change which are very important for the overall sustainability of the globe. A survey on consumers preferences revealed that consumers like to buy products with country of origin, limited environmental impact and expressed their willingness to pay higher prices for these products (Matrix Insight Ltd, 2013)

Different international standards, legislations, dictionaries, and different scientific articles define traceability differently. A very practical and widely used definition of traceability is found in the International Standardization Organization (ISO) 8402 (ISO, 1994) where traceability is defined as: *"The ability to trace the history, application or location of an entity by means of recorded identifications."* This definition clearly states what should be traced and also how the tracing should be done. It is also specified that traceability should consider the origin of raw materials and parts, the processes, the distribution, and the final location of the product (Germani & Mandoli, 2015)

Leather Working Group (LWG) and Institute of Quality Certification for the Leather Sector (ICEC) are two of the globally accredited bodies that certify different business entities in leather sector for having traceability of their products.

In Bangladesh, tanning industry is one of the country's oldest industrial sectors which has huge potential to contribute to the national economy. Since its inception, this industry has undergone several modifications such as expansion of the global market, diversified consumer community etc. On the one hand, this modification has created lots of opportunities and prospects for this sector. On the other hand, it put several new challenges to the sector to cope with the global demand.

Among several other challenges, the traceability of hide is going to emerge as a new challenge for the tanning industry Bangladesh because it has been considered as one of the key requirements to export the product in the high value market.

In Bangladesh, at present, the condition of the industry is far behind in meeting the standard requirements to comply with traceability which makes the sector more challenging compared to their counterparts in the global market. There is an existing national policy which does not necessarily cover how traceability system in tannery industries of Bangladesh will be implemented and there is also a lack of implementation of existing legislations in the tanning industries. Along with that, the existing roles of stakeholders are also not conducive to the implementation of traceability system in the tannery industries of Bangladesh. In the future, without traceability certification, it will be extremely difficult for Bangladesh to be competitive in the global leather market. And traceability would be considered as one of the most crucial factors in establishing a viable leather sector.

In this thesis, the key challenges to introduce an upstream traceability system in tanning industry in Bangladesh have been explored based on the current requirements of Leather Working Group (LWG) audit protocol for traceability compliance followed by some necessary recommendations for implementation. To this end, the current supply chain of hide in the country, probable investment cost, availability of technology and equipment, and above all, the roles of the stakeholders and national legislations have been taken into account.

1.1 Background

Bangladesh is a developing country whose economy is mainly dependent on RMG export and foreign remittance. As the country has the vision to improve its' economic status as a developed country by 2041, there needs to be diversification in the export sector along with improving other factors affecting the economy of Bangladesh. Towards this end, leather industry would be the best option for the country as currently, it is the second largest source of export earnings of Bangladesh, after readymade garments.

According to a study by EBL Securities, Bangladesh produces about 350 million square feet of leather each year, of which 20 to 25 per cent is used locally while the rest is exported. The World *Footwear Yearbook 2020* lists Bangladesh as the eighth largest producer and 18th largest exporter of footwear. The country's export of leather and leather goods was worth $941.7 million in FY 2021, representing 2.4 percent of the country's total export earnings ($38.8 billion) (Theuws, 2022)

According to the 2021-2022 FY annual report of LFMEAB, the overall export earnings from the leather sector has increased by 27% in FY 2021-2022 than that of FY 2020-2021, and it is expected that it will be upward trending in the coming years as well which is very good news for the country. However, a concerning picture is shown in the Figure 1 below which compares Bangladesh's export earnings of leatherwear with the finished and semi-finished leather from the year 2010 to

2020 (in million USD). It is obvious from the figure that the export earnings from leatherwear are increasing with an exception in 2020 due to Covid-19 pandemic when production was halted, and many buyers canceled their orders. On the other hand, even though Bangladesh is one of the largest producers of raw hide, it's export earnings from the finished and semi-finished leather have been declining steadily from 2014 which is very alarming for the sustainable existence of this sector in the global market (Theuws, 2022) It is worth noting that most of the prominent footwear manufacturers in Bangladesh who export their products to foreign countries do not collect raw materials i.e., finished or semi-finished leather from local tanneries due to non-conformity to international standards which is a very disappointing issue for the overall leather sector of the country.

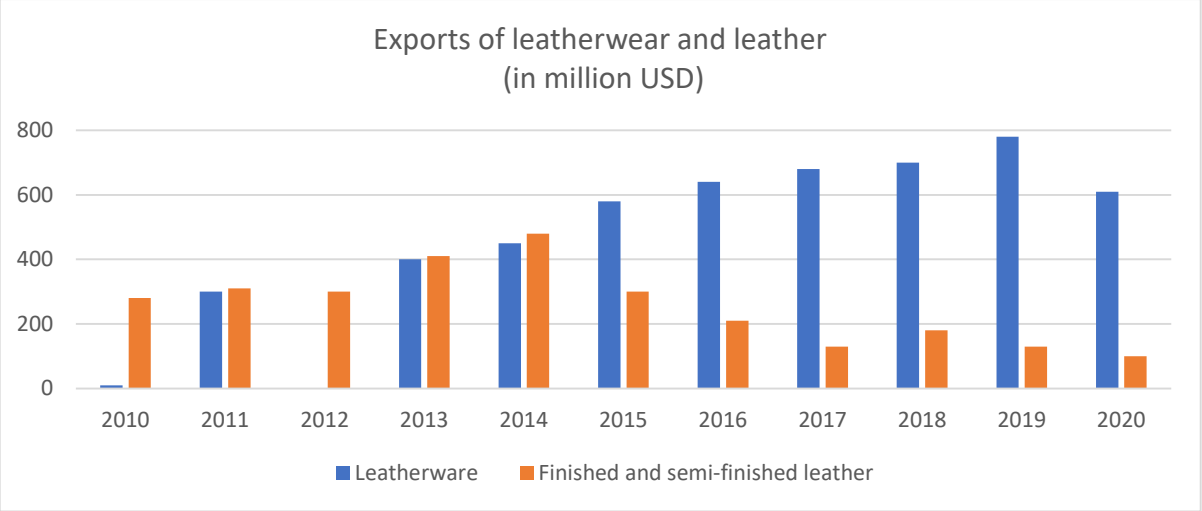

Figure 1: Bangladesh's export earnings of leatherwear, and finished and semi-finished leather from 2010 to 2020 (in million USD) (Theuws, 2022)

Tanneries in Bangladesh are producing a notable amount of finished and semifinished leather but that does not necessarily contribute to increasing export earnings due to non-compliance with some international certification like LWG which is one of the key requirements to export in the high value market. So, prominent international buyers are losing their interest in placing orders for finished and semi-finished leather due to the lack of several compliance issues including environmental, and transparency and traceability in the supply chain. Rather majority of the semi-finished leather is being exported to China, Hongkong, and other countries at a very low price that ultimately could not contribute the country's economy on a large scale.

There could be several other factors for this fall in the export earnings from finished and semi-finished leather. However, among those factors, in the coming days traceability and transparency

in the supply chain will become the key factors for competing with counterparts in the global market.

1.2 Problem Analysis

The economy of Bangladesh is dependent mostly on RMG export and then on remittance from foreign expatriates. As the country has a goal to raise its' economic status from developing country to developed country by 2041 in a global financial context, there is a need for diversification in the export market and not solely dependent on a single sector. Bangladesh is one of the largest producers of raw hide and hence the leather sector has a high potential to contribute at a much larger scale to the economy of the country.

At present, the world is experiencing a shift in paradigm in consumer products from conventional products to environmentally friendly products. A Business Conditions Survey in 2018 by *World Footwear Yearbook* reports that 56% of the respondents believe that consumers prefer leather products with less negative environmental impact (LFMEAB, 2019). This indicates that now the consumers are highly conscious of the information on environmental impact, social impact, and as a whole the life cycles assessment (LCA) of the products they are consuming. LWG endorsed the COP27 Leather Manifesto most recently, where the group's head urged the world to make leather an environmentally friendly, sustainable natural material that has been produced and sourced responsibly. All these things address the need to introduce an effective supply chain traceability system. Bangladesh is far behind in materializing the above issue, which creates a scope to study in traceability system of leather supply chain in the country.

LFMEAB is one of the key actors in leather industry in Bangladesh that addressed the above-mentioned issue in their report in 2019. They targeted that 50% leather factories to be certified by LWG by 2024 who sources leather from Bangladesh along with promotion for implementing Environmental Management System ISO 14001:2015 in leather industry of the country (LFMEAB, 2019). But still no mentionable progress has been visible, and no study has been done to address challenges on traceability issue in leather industry, more specifically in tanning industry of Bangladesh.

In addition to that, currently there is a national policy named 'Leather and Leather Good Development Policy 2019', which addresses the term traceability but doesn't necessarily cover how traceability system in tannery industries of Bangladesh will be implemented. Moreover, the current roles and responsibilities of stakeholders are also not favorable for implementation of traceability system in tannery industries of Bangladesh.

Therefore, to address the above-mentioned issues, this thesis attempts to find out the underlying factors that hinder the initiatives for implementing upstream traceability in the tanning industry.

This is not very easy task to establish traceability of leather from the very root level considering the overall context of Bangladesh. However, it is necessary to find out the key challenges considering all the aspects along with viable solutions to implement traceability at a minimum required level in tanning industry of Bangladesh.

1.3 Research Objective

The main objective of this research is to investigate the challenges and provide probable recommendations for implementation of traceability system in tanning industry Bangladesh. To do this, the risk of non-compliance with traceability standard should be analyzed qualitatively. Mapping of the tannery supply chain and identification of key actors in each step with their roles have to be done, which will reveal the status of the supply chain in the way of implementing traceability system. Financial benefit is the key motivator for the owners, therefore cost-benefit analysis must be considered to evaluate the investment decision of the tannery owners. Current technology and equipment used for traceability of leather products need to be analyzed with their pros and cons in light of applicability. Factor analysis will be performed on the survey data to reduce the number of perceived challenges to a minimum number of factors. Above all, the necessary laws and regulations and the roles and responsibilities of stakeholders must be analyzed thoroughly to comprehend the situation.
Therefore, to fulfill the research objective, the following research questions shall be answered:

- What is the risk of non-compliance with traceability system in tanning industry?
- How does the hide supply chain work and what is the present status of the supply chain in the context of traceability system implementation?
- What is the current technology and equipment used for tracing hide in the tanning industry?
- What would be the cost and benefit from the owners' perspective to introduce traceability system in tanning industry?
- Who are the key stakeholders and what should they do to implement the traceability system?

1.4 Research scope

The upstream supply chain of a tannery in Bangladesh covers a wide range of steps and activities that starts from farm and ends in tannery. In the context of viability, it would not be rational to consider the full supply chain to implement traceability system at a time. It would be better to set the objectives on a short-term, medium-term, and long-term basis. On the short-term goal, the implementation boundaries could be from hide depot to tannery, in the medium term from slaughterhouse to tannery, and in the long term from farm to tannery.

Therefore, this research does not cover the whole supply chain of hide, and only covers from hide depot to tannery to find out the challenges to implement traceability system. Due to time and other resource constraints, the data collection area was limited, and the sample size was not well enough from a statistical point of view. Due to ethical issues, the name of tanneries and participants could not be disclosed in this thesis report. The result of this research cannot necessarily be generalized due to the small sample size, too much assumption-based quantitative calculations. The implementation of the recommendations made in this research is out of the scope of this research as well.

2.0 Literature Review

Literature on traceability system in leather industry, Bangladesh, have been searched on google scholar, Scopus, and web of science database. To search the literature, “traceability”, “leather”, “supply chain”, “hide”, “challenges”, “Bangladesh” these key words have been used in different combinations.

The authors go through different literature regarding traceability including the historical background of traceability systems, standard definition of traceability systems, what research has been done on traceability systems, and which methods have been used etc. It has been observed that literature regarding leather traceability system is not available at a large extent, hence, efforts have been made to go through the literatures of other sectors like food and fisheries that have gone through the traceability practice earlier. In addition, several websites and news portals have also been scrutinized to get state-of-the-art information and knowledge regarding leather traceability systems. Table 1 shows some of the derived literatures on traceability systems.

2.1 Traceability system

The concept of traceability of products first came out from food supply chain in mid nineteenth when a tragic food scandal happened in USA due to Bovine Spongiform Encephalopathy (BSE) diseases or mad cow diseases (Olsen & Borit, 2012). These scandals got huge media coverage, and increased demands from business partners and consumers relating to documentation and traceability of food. Thus, traceability requirements for food were incorporated into national legislation and commercial standards in many countries. In recent years, traceability has become an important tool not only in the food sector, but also in a variety of areas and sectors to ensure product safety to the consumers.

Though traceability is now very commonly used terminology in the business arena, a variety of definitions have been found in different international standards, in legislation, in dictionaries, and scientific articles (Olsen & Borit, 2012). All these definitions have their own usages and implications.

A very practical and often used definition of traceability is found in the International Standardization Organization (ISO) 8402 (ISO, 1994) where traceability is defined as: “The ability to trace the history, application or location of an entity by means of recorded identifications.” This definition clearly states what should be traced and how the tracing should be done. However, the term “trace” is not elaborately defined in this definition.

The EU General Food Law (EU, 2002) defines traceability as “The ability to trace and follow a food, feed, food producing animal or substance intended to be, or expected to be incorporated into a

food or feed, through all stages of production, processing and distribution". This definition is often referred to in scientific articles, and it is quite detailed compared to ISO 8402 with respect to what should be traced and followed, and where.

In scientific articles in (Moe, 1998) "Traceability is defined as the ability to track a product batch and its history through the whole, or part, of a production chain from harvest through transport, storage, processing, distribution and sales".

Among the found literatures regarding traceability implementation challenges, (Thakur & Mehta, 2020) did a case study with qualitative methodology and showed the comparison of different types of technologies used to trace the leather in tanning process with their pros and cons, and survivability to find out the best alternative. However, this paper only focusses on the technological issues of the traceability challenges and the study scope was only tanning process. (Chen & Xu, 2022)did a systematic review of literature regarding supply chain management of leather industry using qualitative methods and identifies main themes of sustainable leather supply chains proposing a theoretical framework for future research. Five themes have been identified in this paper are namely drivers, practice, barriers, enablers, and outcomes. This paper outlines regulative pressure, environmental awareness, health and safety awareness as the driver for sustainable supply chain, and claims that technology and unfair trade are the main barriers.

(Reza, 2022) portrays a complete picture of Bangladesh's leather industry's performance, products, tanning, investment, and environmental impact based on qualitative analysis. (Theuws, 2022) has discussed the working condition of leather sector of Bangladesh and the hidden supply chain that means the loopholes and lack of transparencies in the supply chain system in Bangladesh leather industries.

In a literature of food sector, (MIAO , 2010), did both quantitative and qualitative study which identifies the critical success factor (CSF) for implementing traceability system (TS) in chines food industry. (MIAO , 2010), pointed out laws, regulations & standards; government support & guidance; stakeholder knowledge & support; as the critical factor for implementing traceability system. However, Meiyin Miao did not consider technological constraint in this study. (LEE & BAE, 2010) conducted a study on user experience of an online based Agricultural Traceability Information System of Korea, and stated that technological complexity and cost-effectiveness are the main constraints for the success of the system.

The literature involving traceability in fishery sector in Romania, (Dediu & Moga, 2016) claims that lack of adequate policies, the lack of qualified staff, and high cost are the key barriers to implementing traceability system in fishery sector. Though this research states high cost as a potential barrier for traceability system but did not calculate or break down cost-benefit analysis in the paper. Moreover, any technological necessity was not considered in this research.

Table 1: Reviewed literature on traceability system

Sl.	Sector	Title of the paper	Contributors	Methodology Used
1	Leather	Traceability of Hides through supply chain-Norway	Guro Tveit, Maitru Thakur et al. 2019	Qualitative- A case study
2	Leather	Sustainable supply chain management in the leather industry: a systematic literature review	Xiaowei Chen et al. 2022	Qualitative-Descriptive statistics
3	Leather	The Ins and Outs of the Leather Industry in Bangladesh	Manjurul Hossain Reza et al. 2022	Qualitative-Literature Study
4	Leather	Leather from Bangladesh: Indecent work and hidden supply chains	Martje Theuws, 2022	Qualitative-Questionnaire
5	Food	Critical Success Factors for Implementing Traceability Systems in Chinese Food Enterprises	Meiyin Miao, 2010	Qualitative and Quantitative
6	Food	Construction and Management Status of Agricultural Traceability Information System of Korea	Kang oh Lee et al. 2010	Qualitative- survey and descriptive statistics
7	Fishery	Traceability system for lobsters' supply chain: a review finding and method	N Elfiana, I sulaiman et al. 2010	Qualitative-Literature study
8	Fishery	The barriers for the adoption of traceability systems by Romanian fish farms	Lorena Dediu et al. 2016	Qualitative and Quantitative

Most of the above-mentioned research have used qualitative methods of analysis. Though qualitative research can give an in-depth insight about the participants experiences, perceptions and emotions, qualitative analysis has some limitations also: biasness of the researchers and limitations for generalizability for instance (Ritchie & Lewis, 2003). So, a mixed method of

research to dig into the underlying challenges of implementation of traceability system would be the right approach.
After going through the literature, it can be concluded that there is a gap in study which could focus on a holistic view considering all the potential barriers for implementing traceability system. Therefore, this paper focuses on the identification of all the underlying potential barriers.

2.2 Generic benefits of traceability

The definition of traceability can vary depending on the context and application, however regardless of the application traceability leads to some generic benefits. Traceability reduces cost and labor related to the exchange of information between business partners and makes easy access to more accurate and more timely information needed to make better decisions (Olsen & Borit, 2012). Traceability ensures safety to the consumers by guaranteeing the origin of the products and complying with different laws and regulations (Thakur & Mehta, 2020). Traceability can minimize risk in the product safety and increase reliability in critical sectors such as the food, health and consumer product industries (Marucheck A., 2011). In general, traceability is now being used as a tool for risk identification, risk assessment and risk mitigation (Dabbene, 2014).

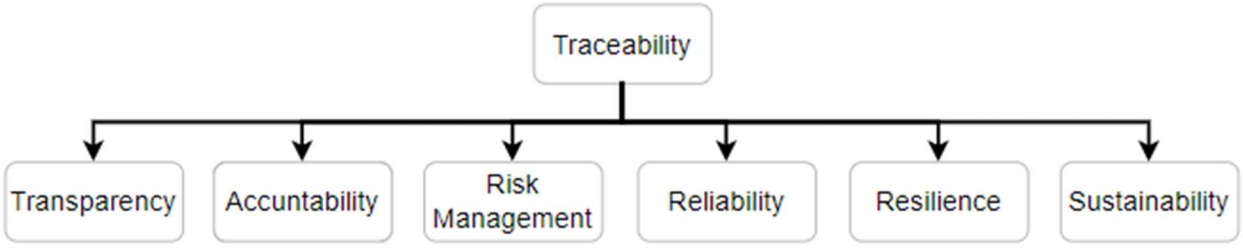

Figure 2: Benefits of traceability in a business process (www.gep.com)

By introducing traceability in a supply chain or manufacturing process, a better process control, an improved error correction capacity, better information sharing, better cooperation among the actors, above all a sustainable business linkage can be achieved (TextileExchange, 2021). In general, traceability ensures transparency, accountability, risk management, reliability, resilience and by this way-sustainability in a supply chain or manufacturing process (Figure 2)

2.3 Traceability in leather industry

Traceability for livestock requires a proper identification of the animal, its country of origin, production facilities and in the best case the place of birth with rearing information (TextileExchange, 2021). In the coming days, tracing of leather products is getting extremely important for manufacturing companies, not only for ensuring safety to the customers and compliance with different standards and regulations, but also for optimizing logistics which ultimately ensure sustainable value chain of leather industry (Cataldo A., 2016). In several consumer surveys and studies, it has been seen that customers are concerned about the genuineness of leather products and often relate the manufacturing country with the quality of the product (Carrier & Jean, 2014). In an assessment based on consumer survey and secondary sources for leather labelling, consumers expressed preferences for products with country of origin and limited environmental impact, as well as expressed their willingness to pay higher prices for these products (European Commission, 2013).

In addition, traceability could be considered as a bridge between the actors in the leather value chain from the farmers to tanners. The quality and grade of hide depend on several activities such as the way of rearing the cattle, feeding, activities at the time of slaughtering etc. Farmers and the butchers are the two important actors in these activities. However, the final quality of the hide is determined at the tannery level. Therefore, without traceability, it is very difficult to communicate and persuade the upstream actors to take care of producing better quality hide.

Besides the generic benefits of traceability that have been discussed in the above section, there are some other aspects that must be taken into account in international standard for traceability in the leather industry. These are animal welfare, environmental and social impact, deforestation and conversion of natural resources, biodiversity and climate change (Figure 3). Establishment of traceability in leather supply chain could create the scope to comply with these issues (LWG, 2021).

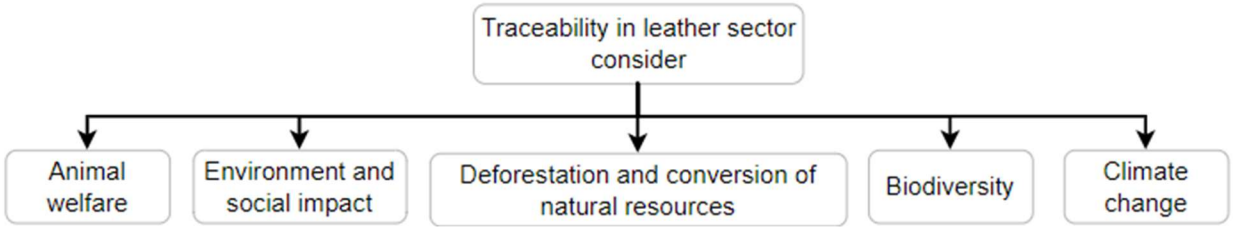

Figure 3: Special aspects of traceability in leather sector (www.leatherworkinggroup.com)

In recent years, social responsibility for the welfare of animals is gradually becoming the social norm (Rolling & Seifert, 2020). Most EU citizens acknowledge and support animal welfare laws within the EU (Donnellan, 2018). Also, most customers care about social acceptability and are less likely to buy exotic leather products made of endangered animals (Teresa & Bonnie, 2006). Animal welfare includes the way of housing, feeding, transportation and slaughtering of animals. Animal welfare also constitutes of the following matters: in the farms, it is expected to have enough staff for looking after the animals along with inspection of those animals at least once a day. The animals will be able to move around, even if confined or tethered, and their accommodation will be clean, with good air circulation and appropriate lighting. A short and swift journey will be provided for animals on transportation, including space, water, feed, and rest. At the time of slaughtering, the animals will be kept comfortable, clean, fed, and protected from injury and distress during the process (one4leather.com, n.d.).

A huge amount of pastureland, food, and water is required for raising animals. According to statistics, over the past half century, 70% of the Amazon rainforest has been cleared for grazing and growing crops. This massive deforestation causes habitat loss for millions of species and drives climate change (www.peta.org, 2023) .

GHG emission coming from farming is a new area of global debate. The most important greenhouse gas in the dairy industry is methane gas from animals that has great contribution on global warming. According to FAO, 14.5% of global greenhouse gas emission comes from farming of animals (ruminants.selko.com, 2023).

Therefore, a successful implementation of traceability system ensures better control over the environmental and social impact induced by leather industry.

2.4 Leather Traceability certification bodies

There are two bodies currently working on traceability certification in the leather industry. These are Leather Working Group (LWG) and Institute of Quality Certification for the Leather Sector (ICEC). A brief description and their protocol of certification are given below:

Leather Working Group (LWG):

LWG, a non-profit organization, came into existence in the year 2005 with the combined effort of a group of brands (such as Adidas, Clarks, Ikea, Nike, Marks & Spencer, New Balance, and Timberland etc.) and leading leather manufacturers across the globe (www.leatherworkinggroup.com, 2022). It is acknowledged worldwide as an indicator for the evaluation of the environmental and social compliance status of a tannery. An LWG-certified tannery is considered an entity that manufactures leather with minimum harming the

environment, using minimal resources, and obliging to global labor rights standards (Moazzem & Ahmed, 2022). As, LWG maintains a strict and transparent audit process, its certification has become one of the key requirements for tanneries to be able to export processed leather, particularly to the market of Europe and the USA. In LWG's audit protocol version 7.0.0, there are 17 components. Some of the key components are environmental management, waste management, traceability, social responsibility, health and safety, and chemical management. Among these 17 components, there are some critical components, some of which are non-critical components. A minimum score must be achieved in each critical section to get a medal award. Traceability is not included in critical sections currently. However, LWG has declared that in their next version of audit protocol, traceability will be included in critical sections. The overall score of these components is 1710 of which the contribution of traceability is 110. There are four categories of LWG certification: audited, Bronze, Silver and Gold, and there is minimum requirement of score for each category to achieve the certification shown in Table 2.

Table 2: LWG certification categories and required percentage of scores (Moazzem & Ahmed, 2022).

Certification Category	Audited	Bronze	Silver	Gold
Minimum requirement (% of score)	50	65	75	85

Institute of Quality Certification for the Leather Sector (ICEC):

ICEC is another specialized institution in the leather sector's certification. This organization has developed a Leather Traceability Certification that assesses the tanneries based on the geographical traceability of the upstream phases of the raw materials (slaughterhouses, breeding farms). This product will be defined in the certificate as having a relevant rating. This rating shall specify the degree of traceability in relation to the process prior to tanneries. The best rating shall be capable of tracing raw hides to the location of breeding farms.

2.5 Types of traceability of leather according to LWG

The leather working group (LWG) classified traceability in 4 types (Figure 4), as part of their leather manufacturer audit protocol. According to that protocol, the material is evaluated and graded on the amount that can be traced back to the slaughterhouse, group of slaughterhouses, or point of collection (LWG, 2021).

The four types of traceability are described below:

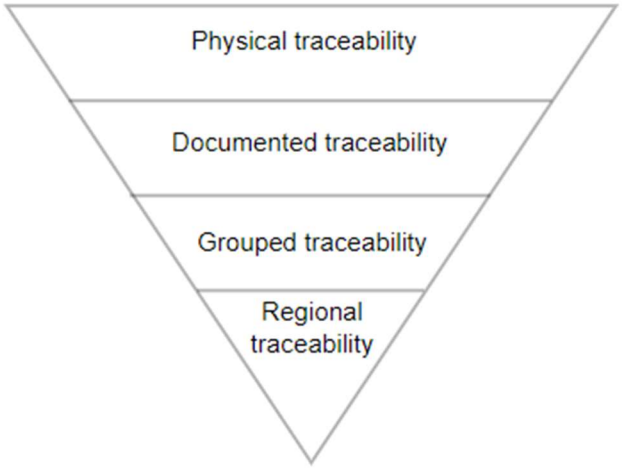

Figure 4: Types of leather traceability (www.leatherworkinggroup.com)

Physical traceability: Physical traceability is achieved through physical marking on the hide or skin, making it possible to trace the product to an individual slaughterhouse. Marking could be done by stamping or laser engraving. Physical traceability is considered the high-level traceability of the material.

Documented traceability: In this type of traceability, material traceability to an individual slaughterhouse is ensured through rigorous documentation.

Group traceability: Group traceability means that material is traceable either though physical or documented means to a group of supplying slaughterhouses.

Regional traceability: This type of traceability means that material is traceable to a geo-referenced point of collection. This type of traceability is applicable where there is no formal slaughterhouse existing. Regional traceability is the minimum level traceability for leather manufacturers according to LWG audit protocol.

Therefore, among the four types, implementation of regional traceability is the easiest one that requires minimum time and effort. However, this is the lowest level of traceability, and only minimum score can be achieved from this type of traceability.

3.0 Research Methodology

This research has been conducted using qualitative and quantitative methods based on both primary and secondary data. Primary data was collected through survey and key informant interviews (KIIs). To gather secondary information a comprehensive desk review was conducted on existing literature, newspapers, and websites. Analysis of secondary information provides an elementary presumption about the present conditions, and challenges of traceability system in tanning industry. At first a draft survey questionnaire was prepared based on secondary information. After that, discussing with the experts the draft questionnaire was finalized to conduct survey. The target respondents and interviewees were owner's representatives, management personnel, compliance officer, and experts in this sector. The interview was conducted using a semi-structured questionnaire. The study area was tannery industrial estate, Savar, Dhaka and two raw hide depots, located at, Postogola, in Dhaka district and in Natore district. Both quantitative and qualitative data were collected from the survey, interview, and literature review. To get a general understanding of the causes and consequences, and preventive and mitigating measures of non-compliance with traceability standards in the light of risk analysis, a qualitative Bow-tie analysis was performed. A private cost-benefit analysis was conducted based on benefit-cost ratio to evaluate the investment decisions for the owners on traceability system. Stakeholder analysis has been done to identify how their roles and responsibilities can affect the initiative to implement traceability system. The data was analyzed using SPSS statistical package 25. Factor analysis was performed to find out the key barriers to establish traceability system in tanning industry. The complete study methodology is shown in Figure 5

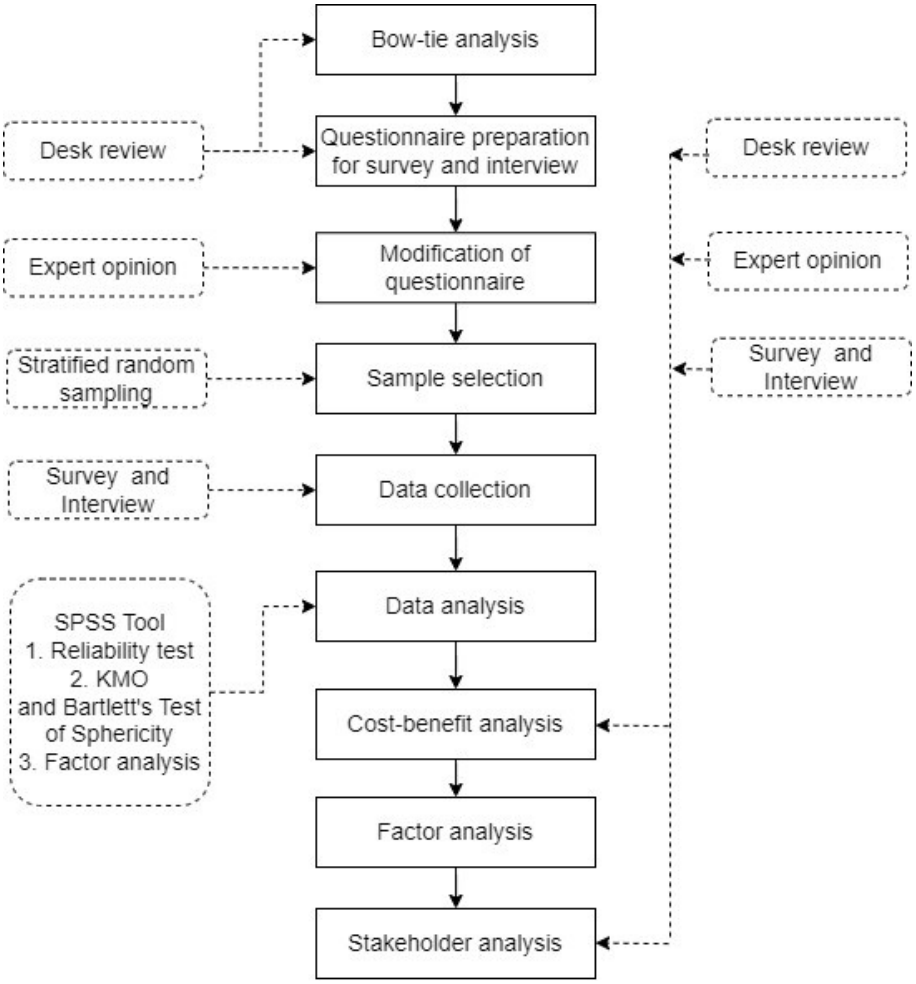

Figure 5: Research methodology of the thesis

3.1 Questionnaire preparation

To perform a survey for collecting quantitative data regarding the challenges of traceability in leather industry, standard questionnaire was searched on websites. However, no such questionnaire was found. Then a draft questionnaire had been prepared based on the information of thorough desk review. After that, the authors met with experts in this area i.e., faculty member of ILET (Institute of Leather Engineering and Technology) and resource person in BTA (Bangladesh Tanners' Association) and discussed about the objectives of preparing the questionnaire. Based on the expert's opinion the draft questionnaire was modified. The final questionnaire has 21 statements on which the opinion of the respondents had been collected (Appendix: A). Since the target respondents was assumed to be educated persons, the questionnaire was made in English language. For collecting qualitative data from the interview, a questionnaire with semi-structured questions was also made in the same process as discussed above.

The questionnaire was made on a five-point Likert scale. The Likert scale is frequently used to measure survey questions where the respondents ranked their degree of agreement or disagreement to a statement or question. To minimize the acquiescence bias of the respondents, four reversely formulated questions are included in the questionnaire. Table 3 shows the five-point Likert scale scoring of positively and reversely formulated questions.

Table 3: Five-point Likert scale scoring of positively and reversely formulated questions.

	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
Scoring of positive questions	1	2	3	4	5
Scoring of reverse questions	5	4	3	2	1

The survey questionnaire has two sections. The first section contains some personal and organizational information about the respondents.

The second section contains statements regarding the perceived challenges for implementation of traceability system in tanning industry. This section contains 21 statements regarding the financial, technological, regulatory, motivational, and several other aspects of the perceived challenges.

3.2 Site selection and survey procedure

The study location for this research were tanneries and hide depots. Most of the tanneries of the country are located in Hemayetpur, Savar, Dhaka district where a dedicated zone for tannery industry is situated which is called BSCIC tannery industrial estate. A very few tanneries are located at Hazaribag, Dhaka and outside the Dhaka district shown in Figure 6 Hide depots are sparsely located in different districts in the country. Among 187 BTA enlisted tanneries, only four are located outside Dhaka which are in Sylhet, Khulna and Chittagong division (BTA & BEI, 2018). There are six major hide depots located in Postogola, Dhaka district, Natore district, Mymensingh district, Jessore district, Chittagong district and Gaibandha district, from which all the raw hides are collected and supplied to tanneries all over the country.

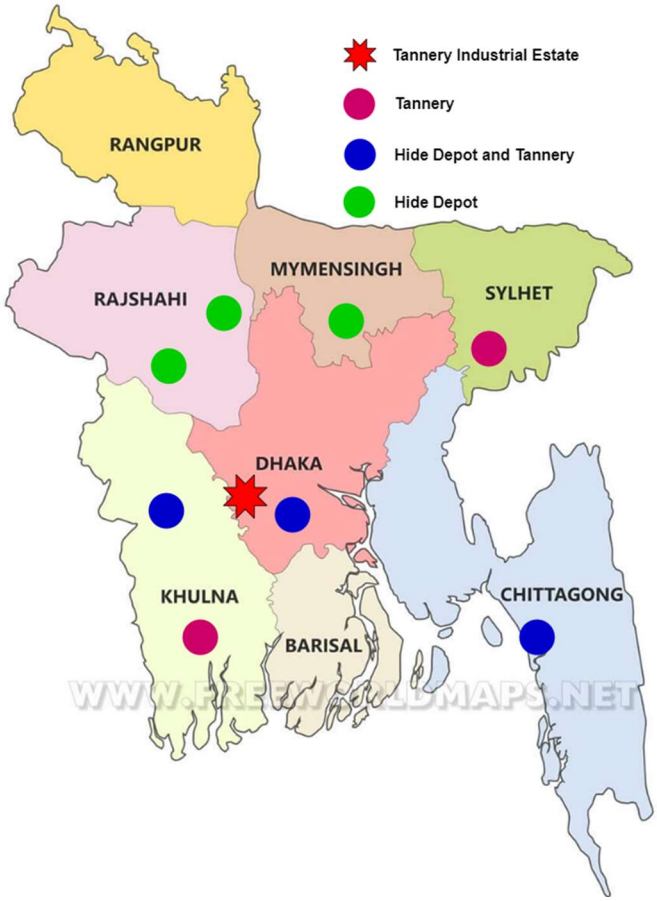

Figure 6: Locations of tanneries and hide depots in Bangladesh.
(Source: BTA and BEI study, 2018)

For selection of tanneries, stratified random sampling method was followed. Based on the information from BTA personnel, the tanneries are divided into two categories: the first category consists of a few factories that already have started working on traceability compliance issues and the second category consists of factories that still have not taken any steps in traceability

compliance issues. Then from the first category five tanneries, and from the second category fifteen tanneries overall 20 tanneries have been selected randomly. The site selection is done this way so that the actual scenario can be derived upon surveying these factories.

After selecting the 20 tanneries, a total of 120 survey questionnaires were distributed to the tanneries. In the first page of the questionnaire, a short introduction and objective of the survey was written. The respondents were assured of their anonymity as well as confidentiality of their opinion. It was ensured that no individual opinion would be presented in any way to the study or to the factory owners.

The survey was conducted in two ways. Firstly, the authors physically visited some tanneries and conducted face to face survey of the tannery personnel and collected the response at once. Secondly, some questionnaires were sent to the tannery personnel through the BTA's representative, and the authors collected the result from the BTA's representative later. Through this survey procedure, finally 84 responses were collected, and the response rate was 70%. Besides the survey, the authors conducted 10 interviews of which 8 were face to face and 2 were over telephone.

3.3 Data analysis procedure

All data analysis and computation are performed using SPSS statistical package 25. Reliability of dataset has been checked using Cronbach alfa value. Eligibility of the dataset for factor analysis is performed. To measure the sampling adequacy, Kaiser-Meyer-Olkin (KMO) test was done. Bartlett's Test of Sphericity is performed to check the correlation matrix.

3.4 Bow-tie analysis:

Considering noncompliance with the traceability system as a critical event, a qualitative Bow-tie analysis has been performed in this research to get a general understanding of the causes and consequences, and preventive and mitigating measures in the light of risk analysis.

Bow-tie is a risk analysis method that is widely used by risk analysts in different practical risk scenarios. Though, bow-tie methodology was first fully used in a Royal Dutch/Shell company in early ninetieth, now a days the application has been spread into diversified field like health care, environment, aviation, banking and so on (Gareth, 2012). A bow-tie diagram represents the relationships between an identified central event usually defined as top event or critical event, its causes and consequences, and the barriers that could be used to prevent the critical event and to control its consequences (Rousand, 2011).

The construction of a bow-tie starts with identifying a center event of critical event from which a consequence searching as well as a cause-searching analysis may be performed. All bow-ties extend out to both sides to include causes on the left and consequences to the right. After that

barriers are placed on both sides of the central event which eliminates or prevent the loss of control on the left side and try to recover from or mitigate the loss of control on the right side (Ruijter & Guldenmund, 2014).

Bow-ties are two types: quantitative and qualitative. A quantitative bow-tie uses a fault tree along with an event tree and barriers to calculate risk. To communicate the risk, qualitative bowties use simpler cause-and-effect scenarios with barriers. (Ruijter & Guldenmund, 2014).

3.5 Cost-benefit analysis

Cost-benefit analysis is a decision-making tool widely used to evaluate the costs and benefits of an investment proposal relating to a project, or any business policy. Basically, there are two approaches of cost benefit analysis: social cost benefit analysis and private cost benefit analysis.

When the cost benefit analysis considers a broader perspective and covers the whole impact of a project of decision on society, it is called social cost benefit analysis. For example, large-scale government projects such as construction of dams, highways, railway lines, power stations etc. consider various economic, social, and environmental factors to evaluate the net impact on society (Suzanne Bonner, 2022).

On the other hand, private cost-benefit analysis considers the costs and benefits associated with individual entities, or businesses. Therefore, cost-benefit analysis can equally be applicable to private organizations that has an implication for the use of large resources. The purpose of cost-benefit is to provide a consistent procedure for evaluating decisions in terms of their consequences (Robert J Brent, 2006).

In this research, a private cost benefit analysis has been performed to evaluate the investment appraisal for implementation of traceability system in tanning industry, Bangladesh which will help the decision-maker to reach a robust decision.

For cost-benefit analysis the present value of future cash flow is calculated according to the following formula:

$$\mathrm{PV} = \sum_{1}^{n} \frac{\mathrm{FV}}{(1+\mathrm{r})^{\mathrm{n}}}$$

Where,

PV=Present Value

FV=Future Value

r=Discount rate

n=Number of years

After calculating the present value of total cost and present value of total benefit through the above formula benefit-cost ratio (BCR) will be calculated using the following formula (educba.com, 2023).

$$\text{Benefit} - \text{Cost Ratio}\left(\frac{\text{B}}{\text{C}}\ ratio\right) = \frac{\text{PV of total benefit}}{\text{PV of total cost}}$$

A Benefit-Cost ratio become greater than one (BCR > 1) then the investment will return profit and it should be considered lucrative to invest in the business endeavor (Pierre Vernimenn, 2009).

3.6 Factor analysis

Factor analysis is a statistical method of analyzing the structure of the interrelationships i.e., correlation among a large number of variables by defining a set of common underlying dimensions (Hair J. & R. Andeson, 1995)

Using factor analysis, the separate dimensions of the structure can be identified which then helps to determine the extent to which variables are explained by each dimension (Hair J. & R. Andeson, 1995). According to (Hair J. & R. Andeson, 1995), factor analysis can successfully be used to summarize the data. Factor analysis discloses underlying dimensions that, when interpreted and understood, describe the data in a much smaller number of concepts than the original individual variables. Therefore, the findings of factor analysis in this context are highly valuable for researchers as it helps the researchers to be more focused and address the key areas more effectively (MIAO , 2010).

Basically, there are two types of factor analysis: Exploratory factor analysis and confirmatory factor analysis. An exploratory factor analysis (EFA) is used when researchers are unsure of the underlying factor structure of variables (Therdoost & Sahabuddin, 2022). Whereas a confirmatory factor analysis (CFA) allows researchers to specify how many factors are necessary and which latent variables are related to which measured variables.

In this research, exploratory factor analysis (EFA) was performed using SPSS statistical package 25 to identify underlying latent variables, or factors, from a set of constructed variables in the survey questionnaire which can explain the key challenges to implement traceability system.

3.7 Stakeholder analysis

Stakeholder analysis is a method of identifying, and assessing, the various individuals, groups, or organizations with a view to evaluating their interests, expectations, and potential influence on a project or decision. Therefore, stakeholder analysis is a crucial subject in the management of a business or a project. In recent business, in addition to profit maximization, the management are highly concerned about the satisfaction of all the stakeholders (Ahsan, D,, Pedersen, S., & Nielsen, M.R.B, 2019),

Likewise, for any business, the success of any new initiative, the leather industry is highly contingent upon satisfaction as well as the roles of the stakeholders. If we look deeper, the concept of traceability system derives from the sustainability which is directly linked with the stakeholders.

According to one of the founders of the stakeholder theory, stakeholders are the persons, as groups, whose contributions are very crucial for the success or survival of a company or organization (R. Edward Freeman, 2002). The stakeholder theory can be descriptive, instrumental, and normative (T. Donaldson & E. Preston, 1995) . In this study, the instrumental approach has been used to identify the stakeholders. This approach primarily focuses on the stakeholder groups who can play key role, positively or negatively, in achieving goal, which is for this case is

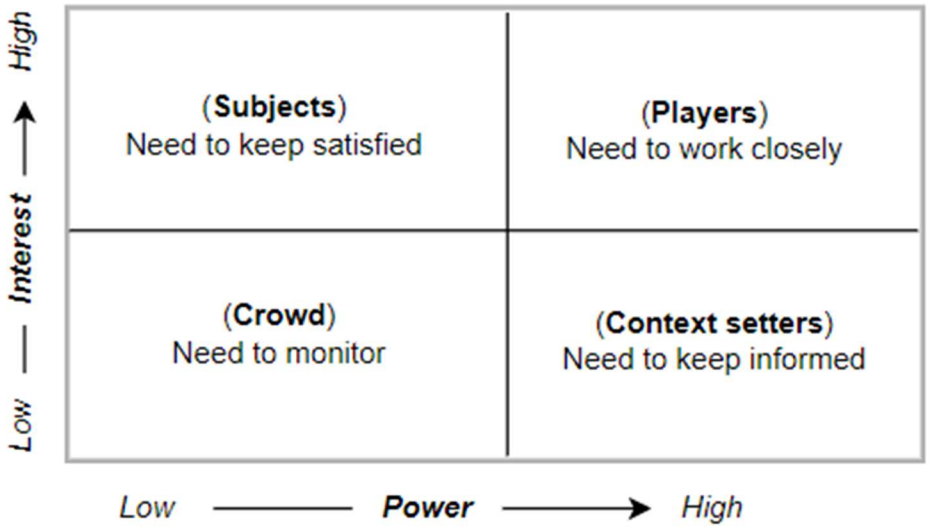

Figure 7: Stakeholder power and interest matrix (C. Eden, F. Ackermann, 2013

implementing traceability system in leather industry of Bangladesh. This approach is used in this study to identify the stakeholders who have interest and power in implementing traceability system in leather sector of Bangladesh. Based on literature, interview and experience, qualitative methods have been used in identifying the key stakeholders. The stakeholder's interest/power matrix, (Figure 7) proposed by Eden and Ackermann, is used in this study (C. Eden & F. Ackermann, 2013)

4.0 Result

4.1 Risk analysis using bow-tie

Bow-tie analysis is an effective risk analysis method which visualizes a critical event and represents a clear overview of possible preventive and mitigating measures to control the event. In this research, desk review revealed that 'noncompliance with traceability standard' has significant negative consequences on the sustainable growth of the tannery industry in Bangladesh (LWG, 2021).

Therefore, considering the above-mentioned issue, 'noncompliance with traceability standard' has been considered in this study as a critical event to analyze risk using bow-tie method. Then a qualitative bow-tie analysis was performed.

Basically, the theory and concept based on which the bow-tie method originated was the industrial point of view where the objects, components, and attributes under consideration for risk analysis were visual and tangible in nature (Dennis Denney, 2012). For instance, in an industrial application of bow-tie, the critical event, causes and the consequence, and the barriers all these things are not soft in nature rather hard and tangible.

The constructed bow-tie is shown in Figure 8 which gives a general overview of the cause, consequence, preventive and controlling measures of noncompliance with traceability of hide in tanning industry. Even though the awareness about the traceability of animal product like leather has been growing rapidly among the consumers in the global market, this study finds several causes for non-compliance with traceability of hide in Bangladesh as pointed out in the bow-tie. The key causes are lack of effective initiative from the government side, complex hide supply chain, huge lack of knowledgeable manpower in this sector and most importantly the owners are not highly demotivation to establish traceability because of lack of proper knowledge and information.

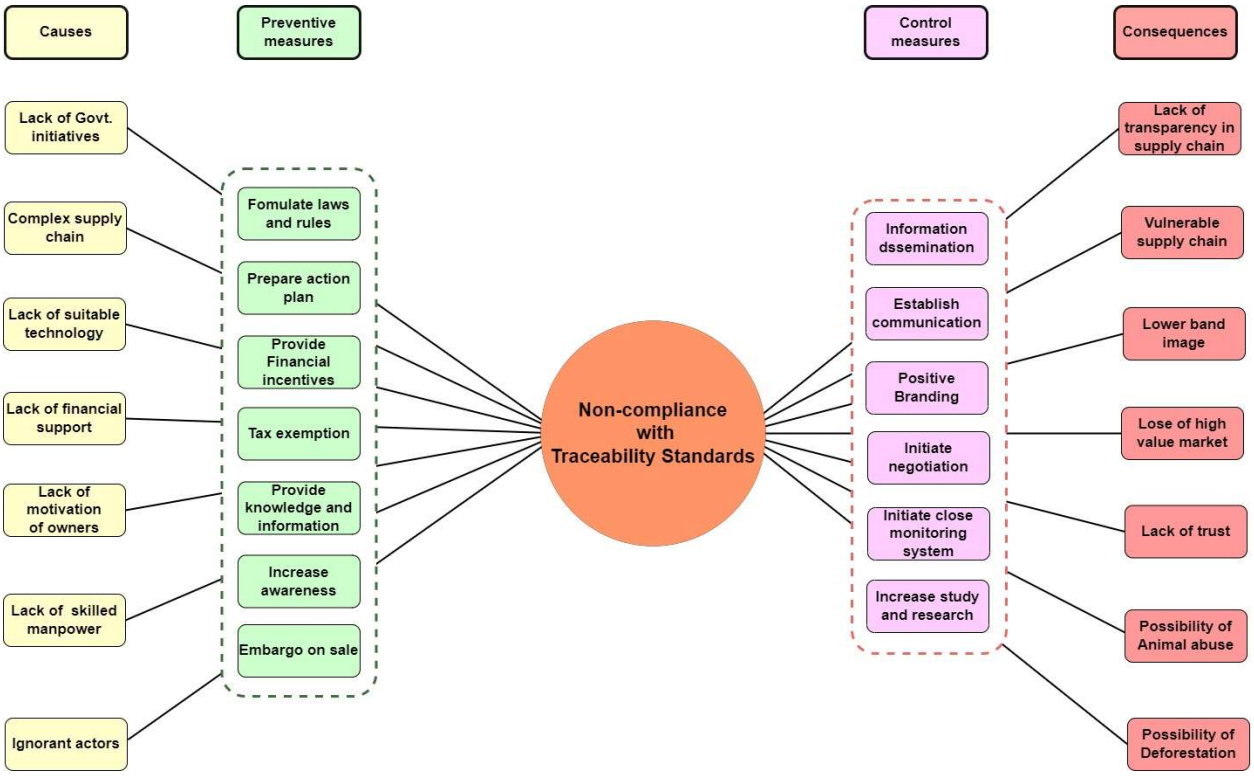

Figure 8: Bow-tie analysis of non-compliance to traceability system

To prevent the causes of noncompliance, several proactive measures should immediately be put in place. The government has not fully realized the importance of traceability yet, but they should enact effective laws and standards regarding this matter with time bound proper plan of action. Infrastructural development activities along with capacity building of the actors must be taken in no time. To motivate the owners 'carrot and stick' motivational approach can be applied. At first, they should provide proper information and knowledge of the benefit to introduce the traceability system with an offer of tax exemption or lowering the tax. If the situation still persists, then actions like high tax impose or embargo on sale the product can be applied.

The major consequences that could arise from the critical event in this analysis are lack of transparency in the supply chain, vulnerable supply chain, lack of trust about the product to the consumers, and the most important one is loss of high value market and prominent buyers that would result huge financial loss. At the same time, lack of traceability of animal products could create the possibility of violation of animal rights, and deforestation (LWG, 2021).

To reduce the consequences, several steps can be taken as depicted in the bow-tie. For instance, to lessen the effect of loss of market and trust of the consumers, strong communication and negotiation has to be established so that they can be informed that initiative has been taken to transform the present situation. By doing this, some more time can be managed to comply with the required standards while keeping the business unchanged. To reduce the consequences like vulnerable supply chain, lack of transparency in supply chain, and negative band image, an alternative way of information dissemination might be used. For instance, frequent meetings with the concerned stakeholder, positive branding in different media can be an alternative way to reduce the consequences and keep the business in a status quo. Animal welfare and animal rights are not very familiar concept in Bangladesh. Therefore, to address the issue, more study and research together with an effective monitoring system must be established.

4.2 Supply chain mapping

Supply chain mapping is the stepping-stone to introduce a supply chain traceability system in a business activity or industrial sector. According to (sourcemap.com, 2023) supply chain mapping is the process of engaging with direct and indirect suppliers, resulting in an understanding of the end-to-end supply chain for a material, a product, or a brand.

In general, supply chain mapping provides several benefits to any business endeavor. It helps to identify and mitigate vulnerabilities in the chain before it happens. For instance, if an actor in the supply chain violates laws and is then banned by the concerned authority, it will eventually affect the whole supply chain that hampers the business activity. Besides, mapping of supply chain strengthens the entire chain boosting the relationship between actors and entities, speeds up the processes by analyzing the connections among the entities, and helps to discover the elements that could highly affect one's business profit. Moreover, it increases the transparency about the products and acquires trust of the consumers. Supply chain has two components' entities with actors, and functions or processes. Entities and actors include producers of raw material, retailers, wholesalers, vendors, intermediaries, transportation, depot. In function and process, activities in an entity by an actor are taken into account (AmericanExpress, 2023).

The concept of supply chain traceability refers to the process of tracking every commercial transaction throughout the end-to-end supply chain in order to determine when and where every step occurred. (sourcemap.com, 2023).

4.2.1 Upstream supply chain mapping for tannery of Bangladesh

Before going to figure out the challenges and to set out a plan for establishing a traceability system, a detailed mapping of the existing supply chain of hide must be done. The key benefits of

implementing supply chain mapping with traceability systems in the leather production chain is increased transparency, which can help to reduce environmental, social, and quality risks as well as enhance credible communication with stakeholders and consumers (LIA, 2021).

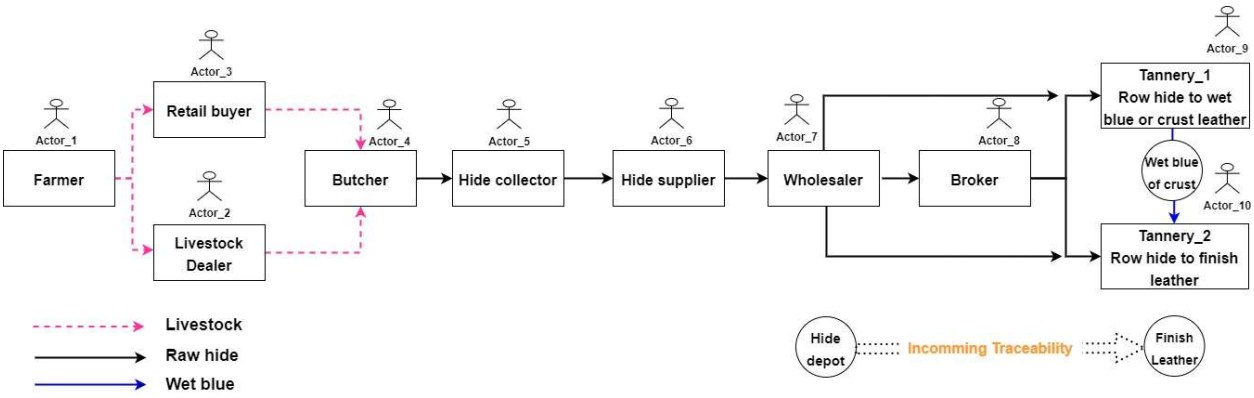

Figure 9: Linear supply chain mapping of hide in tannery (Saleh Shahriar et.al., 2021)

majority of the animals are born and raised in individual farmers house where the farmer rears small number of animals in their house. Figure 9 shows the existing supply chain of hide in Bangladesh. There are also very few farms where a large quantity of cattle is brought up, but the quantity of the farms is very negligible in Bangladesh. In Bangladesh, almost 70% raw hide is collected at the time of Eid-ul-Azha, the second largest religious festival of Muslim community when a huge number of cattle have been slaughtered (BEI, 2018). This raw hide is then collected by hide collectors who sale it to the hide suppliers who later sale it to the wholesaler at the hide depot. At the depot, the primary preservation processes are started like trimming, classification and salting, the process is shown in Figure 10. From the depot, the salted hide directly goes to the tannery or sometime to the brokers who further sale it to the tanneries. Generally, there are two types of tanneries currently functioning in Bangladesh, one types tanneries produce wet blue or crust leather from raw hide and the other types of tanneries produce finished leather, from raw hide as well as from wet blue or crust (BEI, 2018).

Therefore, it has been evident from Figure 9 and from the above discussion that the supply chain of hide is too complex to introduce traceability, because there are too many actors and entity is involved in the chain. On top of that, after conducting an interview with the owner of one depot, it has been understood that the root level actors such as the owners of the depot, suppliers,

collectors and farmers have very poor knowledge about the concept of traceability of hide in leather industry Bangladesh.

4.2.2 Actors and processes in the supply chain

To get a deeper understanding about a supply chain, it is highly necessary to discover all the entities with actors and describe the processes performed by each entity (AmericanExpress, 2023). In the constructed supply chain in Figure 9, it has been seen that there are ten categories of actors who play different roles in the chain which start with farmers and end with tanners.

Farmers rear animals at their house or farm. Then sale it to livestock dealers or individual buyers. Livestock dealers are wholesale buyers who buy a large quantity of livestock from farmers and sale another market in different places. On the other hand, individual buyers collect livestock from the farmers from local market with a view to slaughtering at their home on different occasions. From these two actors the animal goes to the fourth actor who is butcher. At the butcher's the livestock turn into meat and hide. Then comes the collector who collects the fresh raw hide from butchers at abattoirs and from the individual buyers at their homes, and sales hides to the suppliers. Suppliers collect raw hides from different collectors and when the quantity becomes large, sale it to the wholesalers at hide depots. At depots the hides are salted and preserved for a few days before sending it to the tanneries. Sometimes, another actor gets involved between the wholesalers and the tanners: the brokers who buy hide from depot and resale it to the tanners. In tanneries, the hide goes through several harsh processes to become the final finished leather.

The two main hide processing activities have been done at the depot and the tanneries which are within the limit of this study boundary. Therefore, it is imperative to get an overview of the processing activities in each section which will further help to understand the applicability of different technologies used for physical traceability of hides.

In the following sections, the hide processing methods at depot and the tanneries have been discussed briefly.

Hide processing operations in depot

In the hide depots, two types of hides are collected: salted and unsalted fresh raw hide as shown in Figure 10. Then the unnecessary parts of the unsalted fresh raw hides are cut. This process is called trimming of hide. The trimmed hides are then classified according to grade

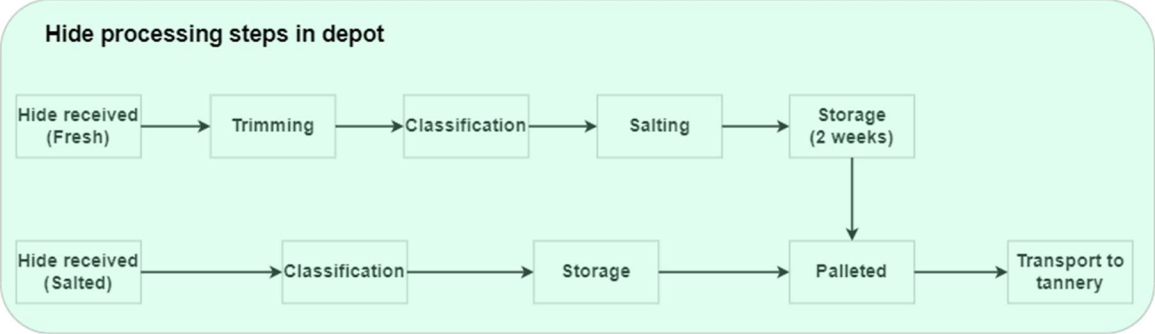

Figure 10: Hide processing operations at depot (Thakur & Mehta, 2020)

which are then salted and preserved for few days before sending to the tanneries. On the other hand, the salted hides are only classified and stored before sending it to the tanneries.

Hide processing operations in tanneries

In tannery, many operations have been performed on hide to transform it to wet blue or crust or finished leather. In Figure 11 the processing of hide in tannery has been shown.

The process starts with soaking the hide. The goal is to remove the salt and other unwanted materials such as dung, blood, soil, etc. In this process, some chemicals such as surfactants, enzymes and bactericides are used with water. The duration ranges from several hours to a few days. After that excess flesh is removed manually or by machine which is called fleshing. The next processes are liming and de-liming. The purpose of liming is to facilitate the removal of hair, flesh, fat, inter-fibrillary protein. In de-liming process, the pH is adjusted in between 8-8.5 in order to enhance the enzymatic activity, which converts some of the proteins into soluble forms. Pickling is a process of correcting the pH suitable for the tanning operation and to prevent swelling of the leather. Then the tanning process starts, the hides are placed into tanning drums with tanning chemicals: usually with chromium sulphate compounds. The duration of tanning depends on the types of tanning that may be ranges from ten to twenty days for chrome tanning. By this processes, wet blue leathers are produced (Mahesh & Sateesh, 2009) .

The above-mentioned processes are most stressful process performed on hide in tanning operation where the hide has to go through harsh mechanical and chemical stressors, and this is the challenging stage for tracking each hide individually because many of the current technical solutions for tracking hide cannot withstand in the rigorous tanning process (Thakur & Mehta,

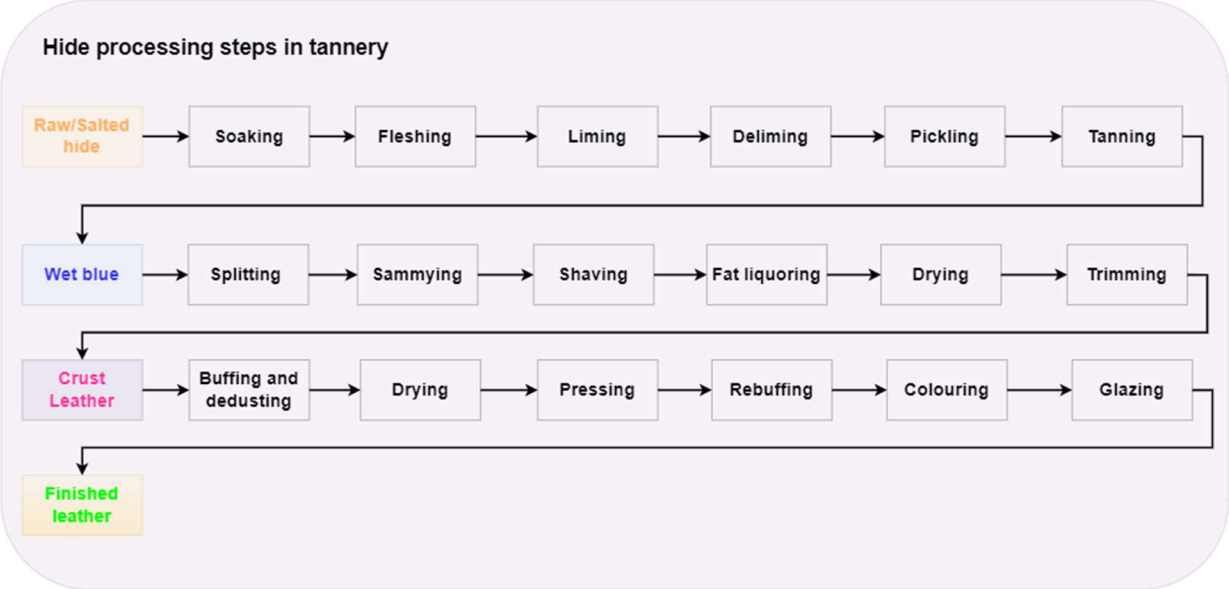

Figure 11: Hide processing steps in tannery (BEI project on trade and investment, 2018)

2020).

The wet blue leather goes through the next four processes namely splitting, sammying, shaving, fat liquoring. In these four processes, the wet blue leather is split into the required thickness, excess moisture is removed, leather is leveled, and synthetic oil is applied to the leather to increase the softness. These processes produce the crust leathers (Mahesh & Sateesh, 2009). To produce crust leather to finished leather, the crust leather has to go a few steps such as buffing, drying, pressing, rebuffing, coloring and glazing (www.leatherdictionary.com, 2022).

4.2.3 Present status of traceability in supply chain

Presently the tannery industry is facing a big challenge to comply with international standards on environmental and social quality, more specifically standards such as LWG certification that consider environmental management system, waste management system, chemical management system, raw material traceability etc. (Moazzem & Ahmed, 2022).

As traceability of raw material is going to be a critical issue for getting certified by LWG in the coming days, the present condition of traceability of raw material in tannery needs to be investigated carefully.

It is evident from the supply chain mapping Figure 9 that there are nine actors involved in the hide supply chain before entering the hide into tannery. And the fact is that one actor only knows their immediate before and after actors, and completely in dark about the other actors in the supply chain. Therefore, if a tanners want to know the location of the farmhouse or the point of slaughter, it is almost impossible to get the information in such a complex supply chain.

To collect information for this research, the authors visited some tanneries, and conducted key informants' interviews. The informants were tanners' representatives, hide depot owners and brokers of the raw hide who supplies raw hide to the tanneries. The interview was taken regarding their knowledge about traceability standards, information about their sourcing practice, technology regarding traceability, view on the importance of traceability etc.

However, excluding some exceptions who imports the raw material from other countries, overall, a disappointing result has come out that most of the tanneries cannot maintain the minimum standard for traceability of raw material sourcing, as per the requirements of LWG. Moreover, those three groups of interviewees have very poor knowledge and information regarding the traceability of raw material in the tannery.

The tanneries which source the raw hide from local sources cannot maintain traceability of their raw material because they collect hide from different hide depots or from brokers from different locations all over the country. Only a handful amount of tannery has been found whose representatives had knowledge about the traceability and they are trying to introduce traceability in their tannery. This study found only one tannery in Bangladesh which has 100% physical traceability of their hide and compliance to the LWG standard, however this tannery imports its raw material from a fully compliance source of another country.

According to the protocol version 7.0.0 of LWG certification the base point for traceability of hide to get the full score would be the point of slaughter of the animal. But currently there is no slaughterhouse in Bangladesh, and the animals are slaughtered at home or at the abattoir which are highly sparse all over the country. After slaughtering and flaying, the hides are gathered in hide depot via several middlemen.

Considering the above-mentioned issues, currently to comply with the minimum requirements of traceability compliance, regional traceability should be implemented in the tannery of Bangladesh. To this end, the hide depot can be taken as the geo-reference point of collection Figure 12 Tanneries must maintain comprehensive documentation for procuring the hide from these hide depots and then put some physical mark on the hides at the tannery premises to identify hides with geo-reference point up to the finished leather.

Figure 12: Schematic Diagram of regional traceability system of tannery (Authors)

4.3 Current technology used for leather traceability

Application of suitable technology could be an enabler for implementation of traceability in leather sector, so it is essential to know the current technology and equipment with their pros and cons used for tracing leather in different stages in supply chain.

There are various types of technologies or equipment currently available in the market which can be used to trace the hide in different stages (LIA, 2021). All these have their own limitations in practical use. Since the hide goes through different types of process at different stages of the supply chain as has been shown in the supply chain mapping, therefore any one of the technologies or equipment cannot exclusively be used through the whole stages of supply chain of hide. Besides, some of the technology is still under experimentation level and not used on a large scale. (Thakur & Mehta, 2020) did a comparative study on the applicability of different tracing methods which can be used to trace hide in tanning process. Table 4 shows the comparison of different tracers with their pros and cons, and the applicability.

Another aspect of these tracers is the method of attachment, that is how this equipment is attached to livestock or hide. Depending on the method of attachment, the tracers can be two types: in-product tracer and on-product tracer (LIA, 2021).

Table 4: Available methods of marking and tracing hides (Thakur & Mehta, 2020)

Marking methods	Required equipment	Does it survive in tanning process?	Cost effectiveness	Feasibility tested in large scale usages?	In-product or on-product	Unique code?
DNA tagging	DNA extraction, PCR amplification instrument	Yes	Only cost effective for	Possible, but not tested	In-product	Yes

	(portable DNA – reader)		large scale usage			
Marking methods	**Required equipment**	**Does it survive in tanning process?**	**Cost effectiveness**	**Feasibility tested in large scale usages?**	**In-product or on-product**	**Unique code?**
Barcodes	Leather Barcode over printer with GS1 prefix	Information not available	Cost effective	Information not available	On-product	Yes
Physical stamping	Gibsson stamper	Acceptable degree of accuracy	Cost effective	Yes, but label is too large	On-product	No
Laser marking	CTC, CO2 laser system	Yes	Not very cost effective	Information not available	On-product	Yes
RFID	RFID tool	No	Yes	No	On-product	Yes
Micro chip	Information not available	Information not available	Not cost effective	No	In-product	Yes
Dot peening	Electromechanical dot pinning machine	No	Information not available	No	On-product	No
Surface tattoo	X-ray instruments	Acceptable degree of accuracy	Not cost effective	No	On-product	No
Hydraulic engrooving	Mechanical hydraulic pressing machine	Yes	Yes	No	On-product	No

In recent years, DNA-based authentication of product tracking and tracing have been emerged noticeably (Sharief & Chahal, 2021). The main advantage of DNA tracking is, its' identity cannot be destroyed without destroying the product. Moreover, it gives a very high standard of proof from a third party that is difficult to match with intra-company paper or data records (M.L. Tate, 2001). DNA tagging can be used for full traceability in leather through the application of synthetic DNA markers at the farm level to the final product in the leather supply chain (www.blcleathertech.com, 2022). One of the main limitations is the expense and sophisticated technology requirement of DNA profiling (M.L. Tate, 2001).

Barcodes have been widely used for long since as an automated data collection technique for tracking and tracing of products in different industrial applications. It is a very cost effective and easy solution for products traceability. This technology has also been used for leather traceability in particular stages but has not been used on a large scale. One main drawback of barcode in hide traceability is that it cannot successfully survive in tanning process.

Traceability of hide using physical stamping by Gibson stampers has been tested. It is cost effective but has not been used widely due to its low survivability in tanning process. Also, there are some other problems with Gibson stampers such as it takes too much area on the leather for labeling, and it does not produce unique numbers automatically (Thakur & Mehta, 2020).

Figure 14: Hide marking with Dot peening machine (Maitri Thakur et.al., 2020)

Figure 13: Hide marking with laser marker (CTC website)

CTC group has developed a high-power CO2 laser marking system through which within a few seconds a 14-character code could be attached to the hide on hair side. It has been proven to be a very efficient way of hide marking through with hide can be traced from farm to finished leather (www.ctcgroupe.com, 2023). However, still now its application is limited to only a few highly developed countries like France, and it not yet very cost effective. Another use of laser for hide marking is laser engraving where the raw hide is engraved with laser before tanning process to make a machine-readable ID on the leather. But the marking cannot fully survive through the tanning process (Thakur & Mehta, 2020).

RFID (Radio Frequency-Identification) tagging technology uses a tag that is attached to a product for tracking and identification of the product via radio waves. When the RFID tag passes through a frequency field of the scanning antenna, it detects the activation signal from the tag and can transfer the information data to another storage without any contact. This technology has been used successfully for tracing or tracking live animals at farms as well as at the time of

transportation. It is very cost effective and widely used technology, however this technology cannot withstand the tanning process (Thakur & Mehta, 2020).

Dot peening is another technology to mark product for creating 2D data matrix on the product. This technology has been tested for tracing hide in tannery. But after tanning the readability of the marking on the hide lost significantly. Therefore, this technology is not applicable in tannery for tracing the hide.

Another way of marking the raw hide is engrooving the hide with hydraulic punching machine. This is a manual machine which can create specific pressure i.e., one, two or three bar pressure necessary for engrooving the hide. The marking can survive successfully in the tanning process,

Figure 15: Hide marking with hydraulic punching machine (Authors collection from tannery)

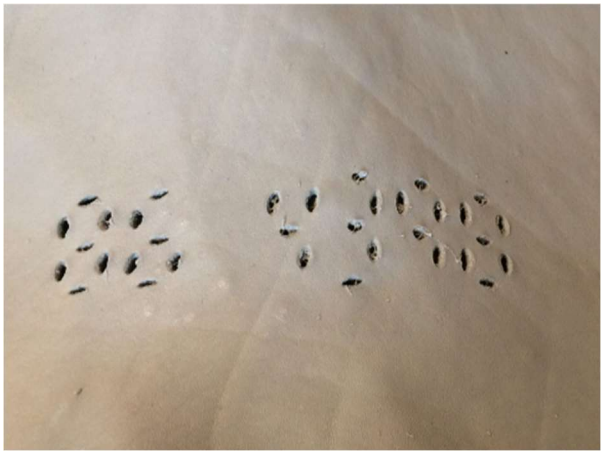

Figure 16: Hide marking with Gibson stamper (Thakur & Mehta, 2020)

and this is a very cost-effective machine. However, the main drawbacks are, it cannot create unique numbers and the process is fully manual and time consuming. Due to its lower price, ease of use and simple technology currently some tanners in Bangladesh are planning to introduce this technology for marking hid in their tanneries.

Therefore, it is evident from the above-mentioned discussion that still there is universal technological solution for traceability of whole supply chain that can overcome all the drawbacks and can be applicable in any country.

4.4 Private cost-benefit analysis

In this section, a cost-benefit analysis has been done to evaluate the investment decision for the owners' point of view to establish a traceability system in tanning industry Bangladesh.

For cost-benefit analysis the present value of future cash flow has to be taken into account. Therefore, the present value (PV) of cost and the present value (PV) of benefit at a discount rate will be calculated according to the equation (1) (Pierre Vernimenn, 2009). The discount rate used for the calculation is 10% and the years of operation has been considered for 10 years.

$$\mathrm{PV} = \sum_{1}^{n} \frac{\mathrm{FV}}{(1+\mathrm{r})^{\mathrm{n}}} \dots\dots\dots\dots\dots\dots (1)$$

Where,

PV=Present Value

FV=Future Value

r=Discount rate

n=Number of years

After calculating the present value of total cost and present value of total benefit through equation (1), benefit-cost ratio (BCR) will be calculated using equation (2) (educba.com, 2023).

$$\text{Benefit} - \text{Cost Ratio}\left(\frac{\mathrm{B}}{\mathrm{C}}\ ratio\right) = \frac{\text{PV of total benefit}}{\text{PV of total cost}} \dots\dots\dots\dots (2)$$

A Benefit-Cost ratio (BCR) >1 for an investment will indicate that the investment will return profit and it should be considered worthwhile to invest in the business endeavor (Pierre Vernimenn, 2009).

4.4.1 Cost analysis

Cost and benefit involved in establishing traceability systems in tanneries can differ significantly depending on their size and production capacity, level of compliance, previous business profile etc. In this research, cost-benefit analysis has been done i.e., benefit-cost ratio has been calculated considering two different assumptions.

First, benefit-cost ratio has been calculated in a deterministic approach under certain assumptions such as the tanneries using same machinery and equipment, exporting to the same market, and will be operated with same lifetime. This is a single point estimation of benefit-cost ratio. Then, a probabilistic estimation of benefits-cost ratio has been modeled using Monte Carlo simulation considering some variability and uncertainty that can be imposed to the calculation (Moazzem & Ahmed, 2022).

The data for this analysis has been collected from interviews with different groups of stakeholders who have special expertise in this area. In cost analysis, two types of cost must be considered i.e., fixed cost and variable cost or recurring cost. It has been described in section 4.2.3 that physical marking on hide is necessary at the tannery for tracing the hide through the whole tanning process. This marking could be done using a pathing machine generally known as punching machine (Moazzem & Ahmed, 2022). If a tannery planned to establish traceability of hide using punching machine the fixed cost will be purchasing cost of the machine and installation cost.
The variable cost items that have been considered here are salary of machine operator and annual maintenance cost. Moreover, a 10% depreciation of machinery has also been taken into account as a variable cost. The purchasing cost of a marking machine depends on different considerations, i.e., types of material used, locally made or exported. One informant stated that, the range of purchasing cost of pathing machine is between BDT 100000 (USD 944) to BDT 500000 (USD 4717) (Moazzem & Ahmed, 2022). Based on the informants interview the cost of other components has been assumed. While calculating the present value and the future cost a 10% discount rate is considered. In table 5, the estimated cost of the investment for traceability has been shown.

Table 5: Break down of cost estimation to introduce traceability (Source: Moazzem & Ahmed, 2022)

Type of Cost (In USD @ a rate USD 1= BDT 106)	**Components**	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**	**Y7**	**Y8**	**Y9**	**Y10**
Fixed cost	Purchase of Machine	944									
	Installation Cost	47									
Total Fixed cost		**991**									
Variable cost	Operator Salary (5% increment)	905	950	998	1048	1100	1155	1213	1273	1337	1404
	Maintenance cost (4% increment)	48	50	52	54	56	58	61	63	66	68
	Depreciation of machinery (10% of purchase price)	94	94	94	94	94	94	94	94	94	94

Type of Cost (In USD @ a rate USD 1= BDT 106)	Components	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Total variable cost		1047	1094	1144	1196	1250	1307	1368	1431	1497	1566
Total nominal cost		2038	1094	1144	1196	1250	1307	1368	1431	1497	1566
10% Discounted cost		2038	995	945	898	854	812	772	734	698	664
Present Value (PV) of total cost	**9410**										

4.4.2 Benefit analysis

Likewise, the cost analysis, for benefit analysis, the data and information were gathered from various literature sources as well as the interviews with key informants. The benefit from traceability compliance will vary from factory to factory depending on the volume of export and the selling price of the product. As the quantity of the exported leather and the selling price is not the same for all the tannery, the benefit might differ from tannery to tannery (Moazzem & Ahmed, 2022). As stated by the key informants, the annual quantity of exported leather varies from 50,000 sq.ft. to 8,00,000 sq.ft. depending on the capacity, size, and business profile of the tannery and the selling price ranges from $ 0.85 to $ 1.35 per sq.ft (BEI, 2018). In this analysis, assumption is made on a tannery whose annual volume of export is around 4,00,000 sq.ft and selling price $ 1.1 per sq.ft. If a tannery achieves compliance certificate from LWG, its selling price will increase by 25% and export volume will be increased by 70%, and overall, 40% price will be increased excluding all costs (Moazzem & Ahmed, 2022). According to above mentioned information, the net benefit for that tannery has been calculated. (Appendix B)

Then the potential contribution of traceability system on the overall benefit has been segregated according to the scoring ratio of traceability on overall score of audit protocol version 7.0.0 of LWG. In LWG audit protocol the overall score is 1710 whereas the contribution of traceability is 110. If a tannery ensures regional traceability (the minimum level), it will get 30% score that is 33 out of 110. Hence, the minimum contribution of traceability on the overall benefit will be 1.92% that is USD 2304 as shown in Table 6

Table 6: Benefit expected from establishing traceability (Source: Moazzem & Ahmed, 2022)

Benefit (In USD @ a rate USD 1= BDT 106)	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Total nominal benefit
Benefit (On overall benefit, 1.92% contribution from traceability)		2304	2304	2304	2304	2304	2304	2304	2304	2304	23040
10% Discounted benefit		2095	1904	1731	1574	1431	1301	1182	1075	977	
Present Value (PV) of total benefit	**13269**										

Table 6 shows that the total nominal benefit is USD 23040 over ten years and the present value of the total nominal benefit after 10% discount is USD 13269.

4.4.3 Single point estimation of benefit-cost (BCR) Ratio

The present value (PV) of total cost and the present value (PV) of total benefit has been calculated USD 9410 and USD 13269 respectively. Then, the benefit-cost ratio (BCR) has been calculated using the equation (2) as follows:

$$\text{Benefit} - \text{Cost Ratio } \left(\frac{\text{B}}{\text{C}} ratio\right) = \frac{13269}{9410} = 1.41$$

This is a single point estimation or deterministic value of benefit-cost ratio. The value of benefit-cost ratio (BCR) 1.41 indicates that the investment to introduce traceability system would be profitable for tanning industries. Therefore, tanneries which are only focusing on other components of LWG audit protocol e.g., environment management system, restricted substance list, waste management, chemical management now could take effective measures to introduce traceability system in their tannery as it has positive impact on overall benefit comparing the costs.

4.4.4 Sensitivity analysis of the investment

Sensitivity analysis is the process by which the impact of one or more input variables on the output variables of a model can be analyzed. The result of sensitivity analysis increases awareness

about the factors which have major effects on the design model. It tests how robust the conclusion of an investment proposal, or a model is and shows which variables exert greater individual (or combined) influence on the conclusion of a proposal or model (O. F. NWANEKEZIE & A. N. IROEGBU, 2009).

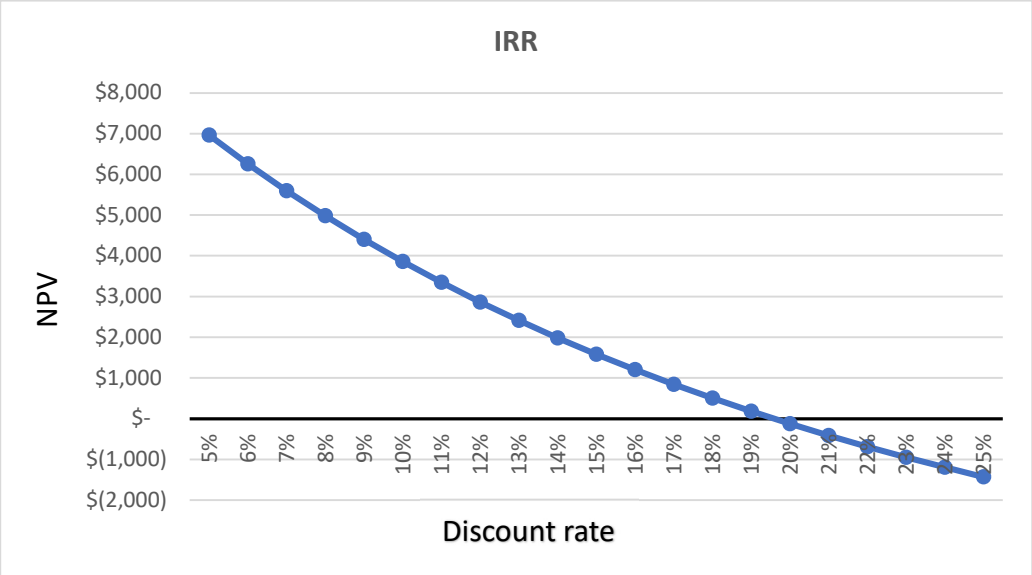

Figure 17: Sensitivity Analysis using internal rate of return (IRR) for the CBA

Generally, in an investment appraisal the variability is evaluated based on a comparison of its Internal Rate of Return (IRR) or discount rate to the financial or economic opportunity cost of capital. In other words, the investment would be considered viable when the Net Present Value (NPV) is positive or benefit-cost ratio is greater than one, using a selected discount rate (O. F. NWANEKEZIE & A. N. IROEGBU, 2009).

Here sensitivity analysis has been conducted based on internal rate of return (IRR) and benefit-cost ration (BCR) to evaluate the investment decision for implementation of traceability system in tanneries. The value of IRR in this analysis has been calculated at 20.7% (Figure 17). On the other hand, in the cost-benefit analysis the discount rate has been considered 10% which is much lower than the IRR. Therefore, significantly higher IRR suggests that the investment has the potential to return benefit.

Sensitivity analysis has also been conducted on benefit-cost ration (BCR) using three different

Year	B/C ratio @ r = 0.05	B/C ratio @ r = 0.10	B/C ratio @ r = 0.15
1	0.00	0.00	0.00
2	0.71	0.69	0.67
3	1.04	1.01	0.97
4	**1.22**	**1.17**	**1.13**
5	1.32	1.27	1.23
6	1.38	1.34	1.29
7	1.42	1.37	1.32
8	1.44	1.39	1.34
9	1.45	1.41	1.36
10	1.45	1.41	1.36

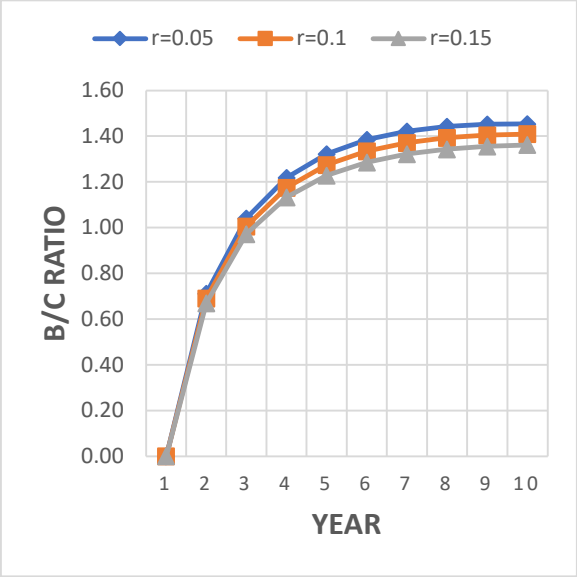

Figure 18: Sensitivity analysis using BCR

discount rates: 5%, 10% and 15% have been used over a ten-year period. (Figure 18). It has been seen from the figure that it needs minimum four years to have benefit-cost ratio >1 for all the three-discount rate. Therefore, the tanneries have to be run for at least five years to get benefit from the investment. After ten years, for the discount rate at 5% and 10% the benefit-cost ratio will be > 1.4.

4.4.5 Probabilistic estimation of BCR using Monte Carlo simulation

In section 4.4.3, benefit-cost ratio for the investment for traceability has been calculated 1.41 as a single point estimation or deterministic approach. Though this single point estimation of modeling is simple to calculate and easier to understand but may be erroneous when making financial planning decision in real life situations because they cannot consider some inherent versatility and uncertainty about the parameter of the model. Therefore, single point estimation could be inadequate or misleading for financial modeling.

As it has been mentioned that the present condition of tanneries in Bangladesh varies significantly in terms of size, production capacity, financial capability, level of compliance, and business profile, that is why their benefit-cost ratio will vary accordingly.

Therefore, considering the variability and uncertainty about some unavoidable situations, it would be rational to consider 25% to 30% fluctuation from the calculated single point value, and to conduct a probabilistic estimation of benefit-cost ratio (BCR). Here, a 30% variation from the calculated value has been considered for modeling a probabilistic estimation.

Now, the assumption could be made that the most likely values of benefit-cost ratio might be the calculated value that is about 1.41, and minimum and maximum values might be in between 0.98 to 1.83 (30% variation). Therefore, this assumption could now be used to model a Monte Carlo simulation to generate probabilistic estimation of benefit-cost ratio (BCR) for the investment projection for traceability system in tannery. For modeling the simulation PERT distribution *pert(0.98,1.41,1.83*) has been used and the simulation has been run using *palisade @risk* software. PERT distribution is widely used to model Monte Carlo simulation to identify risks in project and cost models based on the likelihood. Depending on the provided parameter values, the PERT distribution can provide a close fit to the normal or lognormal distributions (www.riskamp.com, 2005).

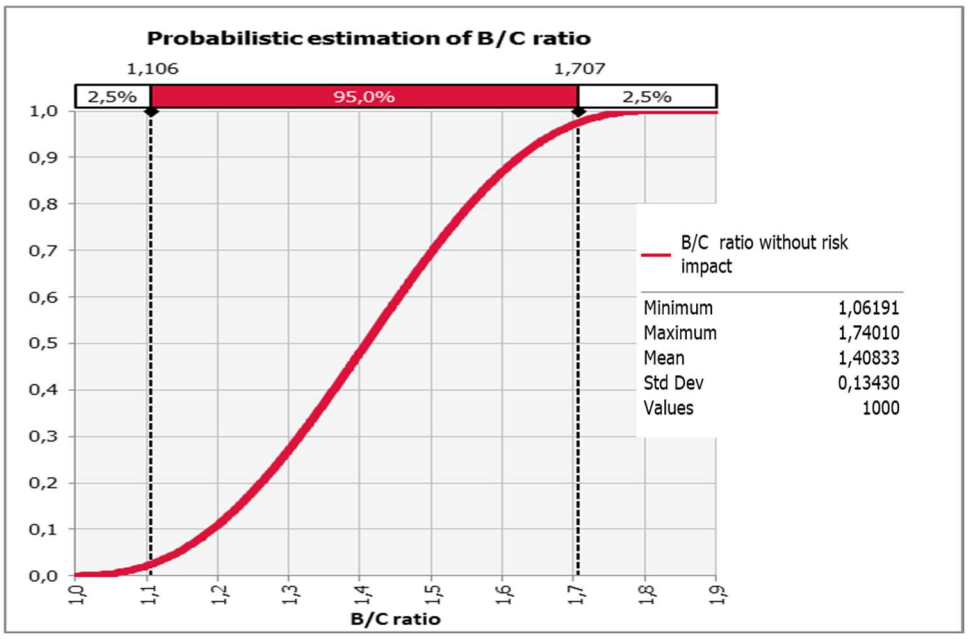

Figure 19: Cumulative distribution of BCR for probabilistic estimation

Figure 19 shows the cumulative distribution of BCR generated by the simulation model from 1000 iteration. This distribution produces all probable values from 0.98 to 1.83. The result shows the minimum value 1.06, mean value 1.4, and the maximum value 1.74.

The model shows that the BCR will never be less than 1. The BCR within 95% confident interval will be 1.1 to 1.7. While in the single point estimation the BCR was 1.41.

Therefore, the tanneries whose level of compliance is better can get more benefit than the single point calculation, and at the same time the variability and uncertainty can reduce the benefit as well. However, there is no chance that BCR ratio to be < 1 according to the model prediction.

4.5 Demographic profile of the survey data

Table 7 shows the respondents profile from the survey data. From the table, it has been seen that the positions of respondents in this survey were manager, compliance officer and others of which the percentage of managers was 20%, compliance officers was 7%, and others was 73%. 'Others' category includes administrative officers, supervisors, technical experts, chemists, and so on. For the sake of simplicity of the survey questionnaire, these varieties of positions are not included in the questionnaire. Though the target respondents for the survey were managerial personnel, compliance officers, and owners, the data illustrates that most of the respondents fell in 'other' category.

Among 84 respondents, 67% were graduates, 25% postgraduate, and 8% were undergraduates (Figure 20). The education profile of the respondents was satisfactory in the sense that 92% of respondents were graduates.

Table 7: Respondents profile of the survey

Position	**Frequency**	**Percentage (%)**
Manager	17	20
Compliance officer	6	7
Other	61	73
Total	**84**	**100**
Education		
Postgraduate	21	25
Graduate	56	67
Undergraduate	7	8
Total	**84**	**100**
Experience		
Less than 1 Yr	4	5
1 to 3 Yrs	21	25
3 to 5 Yrs	32	38
More than 5 Yrs	27	32
Total	**84**	**100**

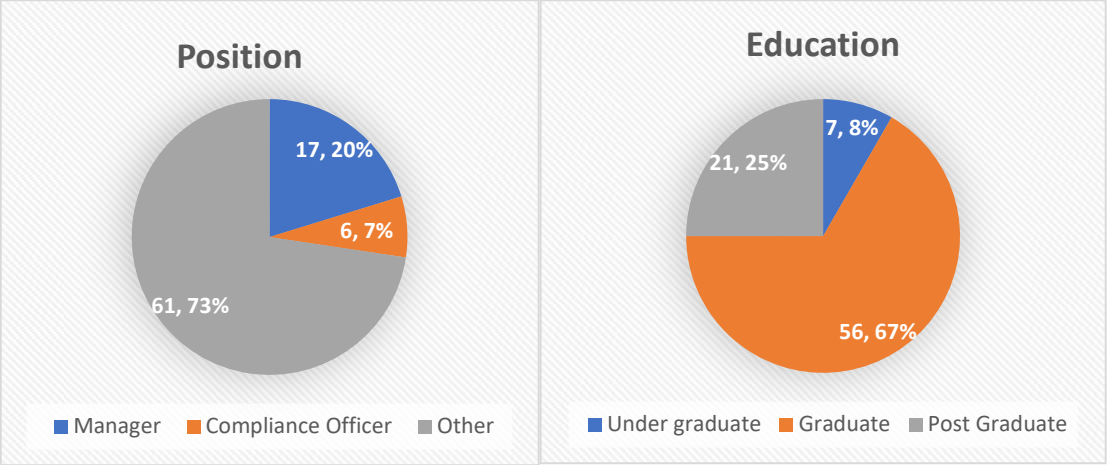

Figure 20: Educational and designation profile of the respondents

The working experience of most of the respondents was more than 3 years of which, 38% had 3-5 years' experience, 32% had more than 5 years', 25% respondent had 1-3 years, and 5% had less than 1 year experience. The experience level of the respondents is acceptable because 70% of the respondents had more than 3 years of experience.

4.6 Descriptive statistics of survey data

For data analysis, at first the reliability of the data has been checked. The Cronbach alfa value was 0.770 indicating that the survey data are consistent for further analysis.

In the survey questionnaire, overall, 21 statements were set as perceived challenges for implementing the traceability in tanneries on which the responses have been collected. Table 8 shows the mean and standard deviation of the scores of individual items. The items in the table are presented in decreasing order of the mean value.

Table 8: Descriptive statistics of the perceived challenges for implementation of traceability

Challenges	Mean	SD
Shortage of knowledgeable manpower	4.42	.496
Absence of slaughterhouse	4.40	.583
Lack of motivation of the owners	4.35	.591
Lack of Act, rules, and guidelines from governments side	4.26	.540
Too many intermediaries in the supply chain	4.14	.697
Lack of study and research are highly necessary	4.10	.722
Ignorance of the root level actor	4.04	.768
Technology is not the main challenge to establish traceability system	4.04	.768
Machineries and equipment required are not readily available	4.01	.814
Lack of coordination among the stakeholders	4.01	.829
Financial inability of the owners	3.94	.766
All actors cannot equally realize the importance	3.88	.884
The industry needs financial incentives from Government and buyers	3.86	.730
Lack of unified plan of action including all stakeholder	3.70	.902
Buyers are not highly concerned about the traceability of our product	3.49	.736
Establishment of traceability system requires huge investment	3.40	.762
Financial capability is not the key challenge	3.31	.944
Lack of technological capability to establish traceability system	3.08	1.153
The return from the new investment to establish traceability system will be very high	2.40	.907
Lack of awareness program	2.35	.685
Lack of easy technological solution in leather industry all over the world	2.04	.525

The Table 8 shows that the respondent's opined shortage of knowledgeable manpower as the top ranked challenge for implementation of traceability system in tanning industry Bangladesh. In a similar study in food sector, (MIAO , 2010) also pointed out stakeholders' knowledge as a critical factor for implementation of traceability system. (Dediu & Moga, 2016) also claims that lack of knowledgeable and qualified staff can be a key barrier for implementing traceability system in fishery sector.

According to the respondent's view, absence of slaughterhouse and lack of motivation of the owners could be another two important barriers for implementation of traceability system in tanning industry.

Lack of acts and rules from the government side have also been identified as the major challenges for implementation of traceability. In food traceability system research, (MIAO , 2010) also stated legislation and rules as important considerate. (Dediu & Moga, 2016), also focused on lack of adequate policies as a key challenge for traceability implementation.

Respondents also agreed with the statements that too many middlemen in the supply chain and lack of study and research in this field are also two important issues for establishing traceability systems in the tanning industry.

The financial capability of the owners has also come out as the challenges for traceability implementation in tanning industry Bangladesh. (LEE & BAE, 2010), conducted a study on agricultural Traceability System of Korea, and stated that cost-effectiveness is one of the main constraints for the successful implementation of the system. (Dediu & Moga, 2016), also agree with the issue of high cost as a barrier for implementation of traceability system.

4.7 Factor analysis (FA)

In this research, factor analysis was conducted on the variables of the survey questionnaire to identify the underlying key factors or challenges for implementation of traceability system in tannery. To this end, the Principal Component Analysis (PCA) was performed on the 21 statements with orthogonal (varimax) rotation. There are two statistical tests to check the eligibility of the data set to perform factor analysis: the Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity. KMO test measures the sampling adequacy and the Bartlett's Test of Sphericity check the correlation matrix. For going through factor analysis, the threshold value or KMO test should be > 0.5 and the p-value of Bartlett's Test of Sphericity should be < 0.005 which tell that the correlation matrix is not an identity matrix. (Darren George & Paul Mallery, 2003)

The initial analysis with the survey dataset showed the KMO value 0.704 that greater than the threshold value of 0.5, and the p-value of Bartlett's Test of Sphericity 0.000 that is the correlation

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.748
Bartlett's Test of Sphericity	Approx. Chi-Square	651.143
	df	120
	Sig.	.000

Figure 21: Eligibility check for factor analysis

matrix is not an identity matrix for this dataset. The initial analysis indicates that the dataset is eligible for factor analysis. Then from the first analysis, five questions with low communalities and low loading factor are excluded. After that, the analysis was performed again that showed the KMO test value 0.748 and the p-value of Bartlett's Test of Sphericity 0.000, as shown in Figure 21 which is significant for the factor analysis.

For extracting the components, varimax rotation with eigen value >1 , and coefficent $>$ 0.5 has been used. Table 9 shows the rotated component matrix of sixteen variables with their loading factor to each component. It has been seen that four components are extracted from the sixteen variables which explains 68.58% of the total variances. The total percentage explainded by the componets is acceptable compared to the same kind of analysis performed by other researchers (MIAO , 2010)

Factor 1 contains 6 variables with Eigen value 4.131 and Cronbach alfa 0.802, Factor 2 consits of 4 variables with Eigen value 3.00 and Cronbach alfa 0.867, Factor 3 contains 3 variables, and component 4 consits of 3 variables (Table 10). The Cronbach alfa value is quite significant for each of the factors. Therefore, the internal consistency among the variables of each factor is quite good. The name of the factors has been chosen subjectively, considering the overall theme of the set of statements or the statement that contains the highest loading in each factor.

The extracted factors are Factor 1 *lack of infrastructure,* Factor 2 *lack of financial support,* Factor 3 *lack of suitable technology,* and Factor 4 *lack of regulatoy measures.* A brief description of the factors and their implications is given below.

Table 9: Rotated factor loading of challenges for implementation of traceability system

		Factors			
		(1)	(2)	(3)	(4)
Challenges	Communalities	Lack of infrastructure	Lack of financial support	Lack of technology	Lack of regulatory measures
The owners are not financially capable	0.839	-0.132	**0.906**	0.324	0.107
The industry needs financial incentives	0.785	0.256	**0.884**	-0.151	0.181
Traceability system requires huge investment	0.766	0.187	**0.857**	0.161	-0.103
Financial capability is not the key challenge[R]	0.638	0.304	**0.789**	-0.126	0.243
Technology is not the main challenge[R]	0.701	-0.167	0.105	**0.765**	0.312
Machineries are not readily available	0.825	0.344	0.119	**0.905**	0.102
We have not enough technological capability	0.788	-0.270	0.365	**0.835**	0.129
Lack of Act, rules, and guidelines from governments side	0.743	0.140	0.139	0.234	**0.818**
Lack of unified action plan including all stakeholder	0.703	0.256	0.168	-0.132	**0.817**
Lack of coordination exists among the stakeholders	0.715	0.309	0.143	0.286	**0.733**
All actors in the supply chain cannot equally realize the importance	0.525	**0.659**	0.134	0.187	-0.196
Absence of slaughterhouse as a requirement of international standard	0.710	**0.819**	0.120	0.118	0.122
Too many intermediaries in the supply chain	0.610	**0.711**	0.265	-0.187	0.312
Huge shortage of knowledgeable and skilled manpower	0.598	**0.757**	0.289	-0.115	0.103
Lack of motivation of the owners	0.537	**0.706**	0.376	-0.140	0.138
More study and research are highly necessary	0.521	**0.538**	0.123	0.209	0.424
Percentage of total variance		25.81	18.75	15.91	8.10
Cumulative percentage of total variance		25.81	44.56	60.47	68.57

R. Reversely formulated

Loading factor > 0.5 are shown in bold

Table 10: Factors with corresponding Eigen value and Cronbach Alfa

Number and statement in the questionnaire		Factor loading by each item (ascending order)	Eigen value	Cronbach alfa
	Factor 1: Lack of infrastructure			
S16	Absence of slaughterhouse is one of the key challenges	0.819	4.131	0.802
S19	There is huge shortage of knowledgeable and skilled manpower	0.757		
S18	Too many intermediaries in the supply chain have made the chain more complex	0.711		
S20	The tannery owners are not highly motivated to establish traceability system	0.706		
S13	All actors cannot equally realize the importance of establish traceability system	0.654		
S21	More study and research are highly necessary to find out a sustainable solution	0.538		
	Factor 2: Lack of financial support			
S1	The owners of the leather industry are not financially capable	0.906	3.00	0.867
S2	The industry needs financial incentives from Government and	0.884		
S4	Establishment of traceability system requires huge investment	0.857		
S5	Financial capability is not the key challenge	0.789		
	Factor 3: Lack of suitable technology			
S7	Machineries and equipment required are not readily available in Bangladesh	0.905	2.546	0.833
S8	Now, we have enough technological capability to establish traceability system	0.833		
S6	Technology is not the main challenge to establish traceability	0.765		

	Factor 4: Lack of regulatory measures			
S10	There is no concrete Act, rules, and guidelines from governments side	0.818	1.297	0.806
S11	No unified action plan has put in place including to establish traceability system	0.817		
S12	Lack of coordination exists among the stakeholders e.g., government, owners	0.733		

Factor 1: Lack of infrastructure:

This factor consists of 6 statements (Table 10) of which *absence of slaughterhouse* carries the highest loading. Other statements are *shortage of knowledgeable manpower, involvement of too many intermediaries, lack of motivation of the owners* and *necessity of more study and research*. All these statements indicate the dearth of infrastructure which includes industrial infrastructure like construction of slaughterhouses, and training and educational infrastructure for capacity building of the stakeholders. Therefore, one of the key challenges for implementing traceability could be the lack of infrastructure in the country.

Factor 2: Lack of financial support:

Factor 2 contains 4 items, all of them are related to the financial issue to introduce traceability system. The items were regarding the respondents' perception about the costing, financial ability of the owners, and need for financial aid from government or from buyer. There was a reversely formulated question (*Financial capability is not the key challenge to establish traceability of hide in tanning industry)* which is included in factor 2. All these statements have a common theme for financial aid government or from the buyers.

Factor 3: Lack of suitable technology:

Since traceability implementation requires some technology or equipment, items related to the usage and availability of those technologies have been included in the questionnaire. Factor 3 incorporates three questions of which one reverse question (*Technology is not the main challenge to establish traceability system in Bangladesh*). These three questions were regarding the insufficiency of technological facilities which have given a common name as lack of technology.

Factor 4: Lack of regulatory measures:

Factor 4 is composed of 3 items about the existence of governmental acts and rules, planning for introduce traceability, and effective coordination among all the stakeholders. All these items manifest the implication of lack of regulatory and planning measures to introduce traceability system in leather sector.

Therefore, after factor analysis, 21 items have reduced to 4 factors or dimensions that could be treated as the key challenges for the non-compliance of traceability system in leather industry Bangladesh.

4.8 Stakeholder analysis

According to (C. Eden & F. Ackermann, 2013), stakeholders can be categorized into four groups, namely players, subjects, context setters and crowd based on their levels of power and interest in the project. Then these four groups can be presented using a power-interest matrix. Among the four groups players have the high power and high interest on the project activities to influence or to be influenced; subjects have high interest but low power; context setters have high power, but low interest and crowd has the low power and low interest on the project.

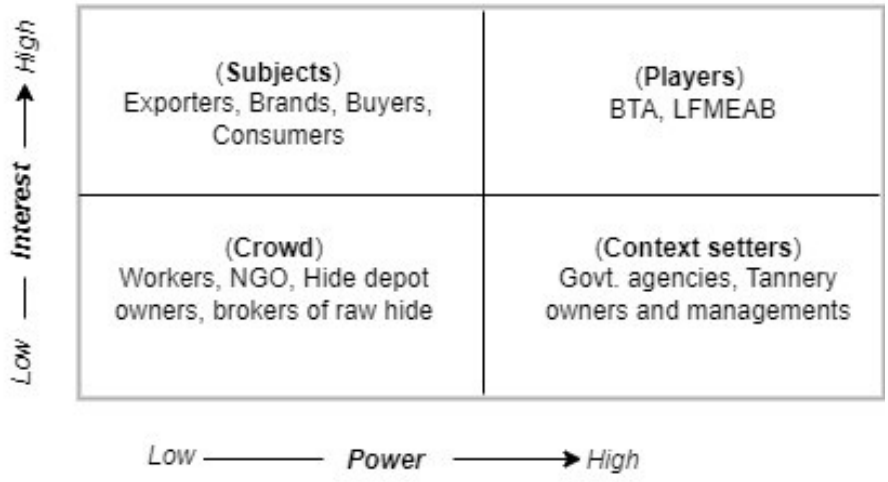

Figure 22: Stakeholder power and interest matrix (C. Eden & F. Ackermann, 2013)

This research is not dealing with the traceability for the whole supply chain of hide that is from the farm to tannery. Hence the stakeholder analysis is done based on the scope of this research which starts with the wholesaler or hide depot owner and broker of the hide and ends with the finished leather at the tannery. For this reason, the stakeholders prior to the scope of this study who are present in the supply chain like farmers, butchers, retail buyers of livestock and livestock dealers, hide collectors are not considered in this stakeholder analysis.

The key stakeholders have been identified based on their current levels of power and interest in implementing traceability system in leather sector of Bangladesh. The identified four groups are presented in a power-interest matrix shown in Figure 22 A brief description of each of the four groups has been given below:

Subjects: Exporters, Buyers and Brands are focusing more and more on traceability systems because the consumers are becoming highly interested in knowing about the origin or source of the product. International organizations who work with global climate and the entities who provide certifications in leather sector like LWG have a direct interest in traceability system of leather industry. But right now, they don't have the power or direct authority to implement traceability system in leather sector of Bangladesh.

Context Setters: Government of Bangladesh along with different agencies e.g., Ministry of industry and Ministry of Commerce has the ultimate power to implement traceability system in leather sector of Bangladesh. Because they are the ones who can make acts, rules, and policies and enforce those legislative tools to achieve the desired outcome. They can also provide support in the beginning to make it possible to implement TS in leather industries of Bangladesh. But their activities do not reflect their interest at this moment. Factory owners and management on an individual level also have the power to implement TS as they are the ones who will directly implement the TS in factories or in the supply chain system of leather sector. But they are not interested in implementing TS because of the lack of motivation and support.

Crowd: Factory workers and NGO have low interest and low power in implementing TS in this sector. Though they are involved in implementing TS in leather industry of Bangladesh, they don't have the influence and interest in implementing TS in Bangladesh. Other groups having the same characteristics are the wholesaler and broker of the hide and hide depot owners.

Players: Owners' Associations (BTA, LFMEAB) are highly interested in implementing TS in leather sector of Bangladesh because failure to do so will cause them to lose the opportunity to compete in the global leather market. They also have high influence or authority as this association is comprised of the owners and investors of leather sector of Bangladesh. Though these associations as an entity have high interest and power because of the willingness of the members of the associations to hold positions with financial capability, all the members are not equally motivated to implement TS at this moment.

However, it should be kept in mind that stakeholder analysis is a dynamic process that should be evaluated and updated on a frequent basis.

4.9 Standard and legislation on traceability system

4.9.1 International standards on leather traceability system

Standards on traceability system for leather basically originated from the initiatives for environmental responsibility in the leather industry (LWG, 2021). Currently, there are two international standards on leather traceability system: standard of leather working group (LWG) and standard of Institute of Quality Certification for the Leather Sector (ICEC). These are two globally accredited bodies who citify leather related business entities in several environmental issues including traceability of leather. Between these two, LWG is the leading body and is acknowledged worldwide as an indicator for the evaluation of the environmental and social compliance status of a tannery. ICEC is another specialized institution for traceability standardization. This organization has developed a Leather Traceability Certification that assesses the tanneries based on the geographical traceability of the upstream phases of the raw materials.

4.9.2 National legislation on leather traceability system

In national level there is no dedicated legislation for leather traceability system. However, there are mainly two authorities who deal with the leather industry of Bangladesh namely Ministry of Industry and Ministry of Commerce. There is an existing legislation named “Leather and Leather Good Development Policy 2019” by Ministry of Industries, Government of the People’s Republic of Bangladesh in which the concept of traceability is brought upon. In this policy, some indications are given to introduce traceability system in leather industry. The sections in the policy related to traceability system in leather industry are presented below:

Section 3.4: Development of Sector and Infrastructure

In section 3.4 actions to ensure infrastructure and sector development are illustrated and traceability system is highly contingent upon the development of infrastructure and sector.

In order to be competitive, necessary investment will be encouraged to modernize the infrastructure of the leather industry. Steps to be taken for capacity building on traceability systems of each leather production a sustainable way throughout the total value chain and it would be set as a requirement for most of the major brands and retailers. The following sub section also related to traceability system implementation.

3.4.1 Enact law regarding the establishment of modern slaughterhouses identifying specific places instead of approving present practice of slaughtering hither and thither.

3.4.2 Aware the owners of tanneries to upgrade existing production technologies and machinery and to modernize operations and strategies to respond to the quality, codes and environmental demands prevailing in the overseas markets.

3.4.10 Necessary measures to be taken to establish storage to preserve the hides and skins on temporary basis by leather traders.

In section 3.6 the creation of an effective supply chain is mentioned which is linked with the traceability system. The elements covered in this section are depicted below:

Section 3.6 Creation of Strong Backward and Forward Linkages

The creation of strong backward and forward linkages along with the complete leather industry supply chain is imperative to become a major global player. In addition to linkages, particular attention must be paid to the availability of raw hides and overall research and development.

3.6.1 Encourage the formation of clusters to enhance coordination in the value-chain of leather industry.

3.6.2 For skill development at every level of the value chain of leather industry (abattoir, tannery, leather goods) assistance to be given for installation of Capital-Intensive Mechanized Finishing Machinery.

3.6.4 Strengthen diversified initiatives for industrial and technology development including creating strategic alliances, acquiring appropriate technologies, transferring technology to acquire improved technology and building effective linkages within and outside of Bangladesh.

The other mentionable terms in the policy are related to finance and investment. Considering the existing context, traceability system is majorly dependent on the investment in leather sector of Bangladesh. The key points regarding finance and investment are discussed as follows:

Section 3.8 Facilitate Local and Foreign Direct Investment

If Bangladesh wants to reach the level of other leading footwear and leather exporters, necessary steps to be taken to encourage local and foreign direct investment and facilitated.

3.10 Financing and Incentivizing for the Development of Leather Industry

For the development of leather industry, it would be wise to accept projects primarily for research, training, machinery, environmental protection, cleaner production and infrastructure. To increase exports, the process of increasing investment through public and private partnership should be improved.

Therefore, the analysis of the “Leather and Leather Good Development Policy 2019” reveals that the policy manifests several important issues directly related to the implementation of traceability system in tanning industry, however this policy lacks for enforceability.

5.0 Discussion

The objective of this research is to examine the key challenges and to find out probable solution for implementing upstream traceability system in tanning industry of Bangladesh. To fulfill the research objectives, five research questions were set out at the beginning of this paper. In the below paragraphs the research findings have been described briefly.

The causes and consequences of noncompliance with traceability standard need to be known before to find out the key challenges for implementation of traceability system. Considering noncompliance to the traceability system as a critical event, a complete view of all the underlying causes and consequences of non-compliance has been portrayed using Bow-tie analysis. Due to difficulties in getting quantitative values of the elements of this Bow-tie analysis, a qualitative approach has been used. Through the qualitative Bow-tie analysis, all the potential causes and resulting consequences along with preventive and mitigating barriers have been identified. Though the demand for the traceable leather product has been growing rapidly among the consumers in the global market, this analysis finds several causes and the consequences for non-compliance with traceability of hide in Bangladesh. The key causes are lack of effective initiative from the government side, complex hide supply chain, financial inability of the owner, lack of knowledgeable person in this sector and most importantly lack of motivation of the owners to establish traceability because of proper knowledge and information. (MIAO , 2010) in a study on critical success factor for traceability identifies government support, stakeholders' knowledge as some the barriers to traceability system success, similar causes are revealed in this study as well. The major consequences of noncompliance of traceability that have been identified in this bow-tie analysis are lack of transparency in the supply chain, lack of authenticity, lack of trust and confident about the product to the consumers, vulnerable supply chain and the most important one is loss of high value market and prominent buyers that could result huge financial loss. At the same time, lack of traceability of animal products could create the possibility of violation of animal rights, and deforestation.

Supply chain mapping is a crucial part for explaining traceability system in any industrial value chain. In this research, after visiting the tanneries and hide depots, and conducting interviews with the key informants, an upstream supply chain of tanneries has been drawn pointing out each entity and actors in the chain. Considering the full supply chain, the supply chain of tannery starts at the livestock farm and ends at the tannery. So, farming of cattle is the first activity and tanning is the final activity of this supply chain. This study finds that there are nine actors and entities involved in the tannery supply chain activities, which is almost similar to the findings of (Saleh Shahriar & Sokvibol Kea, 2021) where he stated that there are seven actors involved in the

production flow of tannery value chain in Bangladesh. In Bangladesh, formal farmhouse is hardly found, and most of the livestock are reared in dividual level which is highly scattered all over the country. Each actor in the supply chain works as an independent standalone entity and does not have proper knowledge about the functions of the whole value chain. And the fact is that one actor only knows their immediate before and after actors, and completely in dark about the other actors in the supply chain. Therefore, if a tanners want to know the location of the farmhouse or the point of slaughter for their product, it is almost impossible to get the information. Here only two actors, the farmers who produce cattle and the butchers who produce hide are the producers in this chain, and the rest others work as intermediaries which make the supply chain very complex in the context of traceability.

Use of appropriate technology is highly necessary to establish traceability systems in the leather industry successfully. If the right technology is used effectively in any sector, it could be an enabler, otherwise it turns out as a barrier to do the work. With a view to getting a concreate idea about the current technology and equipment used for traceability of leather, a detailed description has been given with pros, cons, and applicability of each technology and equipment. (Thakur & Mehta, 2020) did a comparative study on the applicability of different tracing methods which can be used to trace hide in tanning process. There are various types of technologies or equipment currently available on the market such as RFID, laser, dot pining, hydraulic punching etc. which can be used to trace the hide in different stages. All these have their own limitations in practical use. Since the hide goes through different types of process at different stages of the supply chain as has been shown in the supply chain mapping, therefore any one of the technologies or equipment cannot universally be used through the whole stages of supply chain of hide which results the implementation of traceability very challenging. In this study ten types of technologies have been described as a tracer of hide and leather. Some of these are highly sophisticated, costly, and can produce unique numbers that can be quickly readable through machines. On the other hand, some of these are less sophisticated, cheap, but cannot produce unique numbers and the number cannot be readable by machines which makes the process laborious. Moreover, some of the technology is still under experimental level and not used on a large scale. (LEE & BAE, 2010) in a study, claims that technology could be a barrier to implementation of traceability if suitable technology is not available or adopted. (Thakur & Mehta, 2020) find in their study that technology can be a challenging for traceability of hide in the tanning process as in the tanning process the hide goes through some rigorous processes.

Financial benefit is the first matter of consideration for an investor to invest in any new business endeavor. Introducing a traceability system requires additional investment for the owners of the tannery. And new investment is always subject to uncertainty about the benefits. (LEE & BAE, 2010), conducted a study on the agricultural Traceability System of Korea, and stated that cost-effectiveness is one of the main constraints for the successful implementation of the system. (Dediu & Moga, 2016), also agree with the issue of high cost as a barrier for implementation of traceability system. Therefore, a cost-benefit analysis had been conducted from the tannery owners point of view that could help them to take the investment decision. In this research, the benefit cost ratio has been calculated to evaluate whether the investment decision is worthwhile or not. Two different approaches have been used to calculate the benefit cost ratio, these are: single point estimation and probabilistic estimation. Single point estimation results the benefit cost ratio 1.41 which indicates that the investment is worthwhile. On the other hand, in probabilistic estimation, some variability of the tannery profile has been considered such as the size, production capacity, current level of compliance etc. The probabilistic estimation reveals with a 95% confidence interval that the benefit cost ratio will be in-between 1.1 to 1.7, and there is no chance of benefit cost ratio be less than 1. Sensitivity analysis has been conducted for the cost benefit analysis with internal rate of return (IRR) and benefit cost ratio (BCR) over a ten-year period. The value of IRR (20%) is sufficiently high compared to the assumed discount rate (10%) which indicates that the investment is worthwhile. The benefit cost ratio has also been calculated for sensitivity analysis with three discount rates as 5%, 10% and 15%. The result showed that a minimum of four to five years is needed to get benefit from the investment.

Factor analysis had been performed on 21 variables to explore the latent variables or factors that could be considered as the key challenges to introduce traceability system in tanning industry of Bangladesh. Four components i.e., factors have been extracted from the twenty-one variables which have eigen value greater than one. Looking into the variables of high loading of each factor, the four factors have been named as: *lack of infrastructure*, *lack of financial support*, l*ack of suitable technology* and *lack of regulatory measures*. These four latent variables or dimensions are the main challenges to introduce traceability system in tanning industry Bangladesh.

Four group of stakeholders have been identified in the stakeholder analysis based on their impact (namely power and interest) on implementing traceability system in the tanneries of Bangladesh. “Subjects” consists of exporters, buyers, brands, consumers, and international entities like LWG who have high interest but low power in respect of implementing traceability system in the tanneries of Bangladesh. The group “Context Setters” are the ones who have the authority or

power to implement traceability but right now, they have lack of interest. Government agencies of Bangladesh like Ministry of Industries and Ministry of Commerce, individual factory owners and relevant management personnels fall under this group of stakeholders. In the stakeholder analysis, “Crowd” group consists of factory workers, NGO who work with environmental protection and animal rights, the hide depot owners, the wholesaler, and broker of the hide, who do not have the power and have no interest regarding traceability in the leather sector at this moment. Two organizations namely BTA and LFMEAB are the “player” group that have both the high interest and the high power subjected to collaboration with the government to implement traceability system in leather sector of Bangladesh. The findings of the stakeholder analysis are not static as it is a dynamic process and hence the roles and responsibilities may vary depending on time and context.

From the legislative part, it has been revealed that there are two international standards for leather traceability system: standard of leather working group (LWG) and standard of Institute of Quality Certification for the Leather Sector (ICEC). These are two globally accredited bodies who citify leather related business entities according to their own set of protocol in several environmental issues including traceability of leather. Between these two, LWG is the leading body and is acknowledged worldwide as an indicator for the evaluation of the environmental and social compliance status of a tannery.
In national level there is no dedicated legislation for leather traceability system. However, there are mainly two authorities who deal with the leather industry of Bangladesh namely Ministry of Industry and Ministry of Commerce. There is an existing legislation named “Leather and Leather Good Development Policy 2019” by Ministry of Industries, Government of the People’s Republic of Bangladesh in which the concept of traceability is brought upon. In this policy, some indications are given to introduce traceability system in leather industry.

6.0 Recommendations

This research finds the four challenges to implement traceability in tanning industry Bangladesh. The challenges are '*lack of infrastructure*', '*lack of financial support*, '*lack of suitable technology*' and '*lack of regulatory measures*'. To overcome these challenges, a concerted effort needs to be made with all the stakeholders. Government and the owners have to play the leading role in this case. In the following paragraphs, the four challenges have been discussed in detail with necessary measures to tackle the challenges.

1. Lack of infrastructure

Both the institutional and industrial infrastructure have to be developed for successful implementation of traceability system in tanning industry. The research reveals that there is dearth of knowledgeable manpower in this sector in all levels. To address this issue, capacity building activities must be taken including all the key actors. Education and training institute in this field must be increased with a view to increasing the academia-industry collaboration. At the factory level, capacity building initiatives must be implemented with the assistance of experts' knowledgebase in this sector. At the institutional level more study and research opportunities must be created for continuous improvement.

Industrial infrastructure must be developed including construction of slaughterhouses in the quickest possible time that will reduce the complexity in the supply chain in the context of LWG requirements. It has been illustrated that LWG has four types of traceability certification of which three required formal slaughterhouses in the supply chain from where hides are traced. Only the regional traceability certification does not need formal slaughterhouses, but comprehensive documentation is needed about the point of collection or geo reference point which satisfy the minimum level of traceability. Since there is no formal slaughterhouse in Bangladesh right now, therefore, only regional traceability requirement can be achieved by the tanneries in the country. To do so, at first rigorous documentation is to be maintained for procuring the raw hide from different locations of the country, and then at the tannery physical marking is needed on the hide to identify the collection point or geo reference point of the hide.

Therefore, the hide depots from where the bulk amount of hide has been collected for tanning can be considered as the point of tracing or geo reference point. This can be short term solution for getting minimum level compliance regarding traceability. However, for long term planning, formal slaughterhouses must be built up at suitable locations in big cities or near the hide depots. In all of the above-mentioned cases, the existing roles and responsibilities of the government need to be modified. Government must actively participate in building institutional and industrial infrastructure which will reflect their interest in implementing traceability system in tannery industries of Bangladesh.

2. Lack of financial support

This research finds that the respondents of the survey are concerned about the financial ability of the owners to implement any new initiatives like traceability. It is undeniable that the financial capacity of all the tanners is not the same. Therefore, financial assistance and incentives are necessary for the inclusive development of this sector. Tax exemption or lowering the tax, soft loan, infrastructure development funding, public-private partnership can be the aid from the government side. Government of Bangladesh should come forward in ensuring the financial capability of the owners of tanneries and hide depot to establish traceability system in leather sector of Bangladesh. As currently, they are not showing any act to support the sector financially, immediate measures should be taken from the government's side in financial perspective. In addition, financial collaboration from buyers and brands and foreign aid agencies and countries will substantially improve the financial ability of the owners of the tannery which can positively influence the owner to introduce traceability in the tannery.

3. Lack of suitable technology

Adoption of suitable technology and equipment for tracing leather is very challenging because the processing of leather involves multiple stages. Moreover, each of the current technologies has distinct features, pros, and cons in terms of applicability. Some of these are highly sophisticated, costly, and can produce unique numbers that can be quickly readable through machines. On the other hand, some of these are less sophisticated, cheap, but cannot produce unique numbers and the number cannot be readable by machines which makes the process laborious. Since suitable technology for a factory will vary based on the logistic parameters there should be knowledge built up regarding the technologies and machinery used in this sector and choose the best alternative.

However, in the context of Bangladesh where availability of manpower is not the big challenge, cost effectiveness is the main attribute of consideration. Therefore, after conducting the comparative study and visiting the tannery, it can be stated that currently hydraulic punching is the suitable technology that could be adopted for physical marking on hide before starting the tanning process. Besides, initiatives must be taken to adopt the best possible technology by continuously updating the information and knowledge regarding state-of-the-art technology in this sector.

4. Lack of regulatory measures

Regulatory measures serve as means for governments and regulatory bodies to formulate and implement policies, rules, and acts that an actor or entity must follow. The government of

Bangladesh formulated a policy in 2019 named 'Leather and leather goods development policy' which addressed the key issues such as infrastructure development, development of human capital, and developing backward and forward linkages etc. In these key issues, setting up slaughterhouse, knowledge and awareness raising campaign, and study and research at institutional level have been included. But there is no specific section for traceability system implementation. Moreover, the main bottleneck with the policy is the lack of implementation. Most of the measures that have been suggested in the policy are yet to be implemented. Therefore, a policy without implementation plan cannot bring the desired outcomes. Though government has the authority, but present circumstances do not reflect their interest in implementing traceability system in leather sector of Bangladesh. Government must show their interest in establishing traceability and the most effective way to confirm that is to formulate rules, regulations, act, and policies and to ensure proper implementation of the relevant legislations.

LWG made a road map on traceability of leather sector which they wanted to achieve by 2030. But no such a road map or vision has been taken in local policy or in plan of action in leather sector of Bangladesh yet. Therefore, a time bound plan of action in line with LWG road map with measurable and monitoring indicators, must be taken in no time to implement traceability in tanning sector.

7.0 Conclusion

Leather sector has a great potential to boost the economy of Bangladesh. But to achieve this, international compliance standards must be met to sustain the highly competitive global leather market. Implementation of traceability system in leather industries of Bangladesh can play a vital role to improve the compliance status of the sector, and thus the overall development of the country.

This research mainly focused on finding out the challenges of implementing traceability system in leather sector, more precisely in the tannery industries of Bangladesh and suggesting way forwards to overcome those challenges. In the following paragraphs the accomplishment of the research objectives has been discussed briefly.

A qualitative risk analysis for noncompliance with traceability standard using bow-tie method indicates that there is consequence of financial loss imposed from the noncompliance. Supply chain of tanning industry of Bangladesh has been mapped which reveals that there are nine entities and actors involved in the tannery supply chain, most of which work as intermediaries that made the supply chain more complex in term of traceability implementation. A comparative study of different technologies of leather traceability suggests that there is no universal technology that can be used to trace the whole leather supply chain without any complexity in any context. The result of the private cost benefit analysis represents that the investment to introduce traceability system is worthwhile. Stakeholders' analysis discovered that the Government and the owner are the two key stakeholders for traceability implantation, however they should work collaboratively and more proactively in this regard.

The result of this research unveiled that there are four key challenges for implementing traceability system in the tanning industry of Bangladesh. These four key challenges are: lack of infrastructure, lack of financial support, lack of suitable technology, and lack of regulatory measures.

Infrastructure includes both industrial and institutional infrastructure. Development of industrial infrastructure such as construction of slaughterhouses will reduce the complexity of the supply chain according to the requirements of the compliance authority which eventually facilitates the traceability compliance. Development of educational and training infrastructure will increase the industry-academia relationship which will help to create more knowledgeable and aware stakeholders in this sector which is very important for the successful implementation of traceability system.

Financial insolvency of the owners has come out as another challenge for the implementation of traceability system. It is undeniable that the financial capacity of all the tanners is not the same. However, cost benefit analysis shows that investing in traceability implementation is worthwhile.

Therefore, financial assistance and incentives are necessary for the inclusive development of this sector.

Lack of suitable technology has become another challenge for traceability implementation. The cost-effective technologies used for tracing the hides use laborious and time-consuming processes. On the other hand, hi-tech efficient machineries are very costly that require very high skilled manpower and sophisticated technological environment of operation. However, in the present context of Bangladesh, this research recommends the most cost-effective technology which is the hydraulic punching for tracing the hide for the time being. However, provision should be kept for continuous development of technological adoption in this sector.

This research also finds that the current regulatory framework regarding the leather industry is not very conducive to implementing traceability system in the tanning industry. The 'Leather and leather goods development policy, 2019' addressed some issues such as infrastructure development and development of human capital by setting up slaughterhouse, increasing knowledge and awareness by doing more study and research. But there is no specific section for traceability system implementation. Moreover, the main bottleneck with the policy is the lack of enforceability procedure.

This research provides some implications to policy makers as well as investors for implementing traceability system in the tanning industry. The policy makers must formulate some short-term and long-term road map and plan of action aligned with the traceability road map of international organizations to overcome the identified challenges. A short-term goal should be meeting the requirements to get the minimum level compliance as soon as possible, whereas the long-term goal should be achieving the highest level of compliance. However, these initiatives must be implemented through official enforcement. Because a policy or plan without enforceability cannot bring the desired outcomes. This research also highlights the risk of noncompliance to traceability system in terms of individuals' business perspective. The investors must fully understand the requirement of the certification, causes and consequences of noncompliance, and must follow the national and international standard and policy. The analysis of this research helps the investors evaluate the potential cost and benefits, and problems and prospects associated with the investment appraisal which eventually guides them to reach an informed decision.

Therefore, the results of this research make valuable contributions to the understanding of present status, the key challenges, and the possible solutions for implementation of traceability system in tanning industry of Bangladesh.

8.0 Further research scope

Traceability system is literally a very new concept for most of the tannery factories of Bangladesh. This study has tried to fill the research gap to identify the key challenges to implementing traceability system in the present context of Bangladesh. However, this paper only considers a portion of the total value chain of the leather market of Bangladesh and recommendations are made to achieve the minimum level of compliance in traceability system. So, there is a huge scope to broaden the research boundary including the whole leather value chain. More respondents can be reached to gather more information to study further. There can be more research and study to develop a standard survey questionnaire to conduct a more comprehensive survey that could lead to develop a complete framework for implementing the traceability system in leather value chain in Bangladesh.

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Appendix A: Survey Questionnaire

Survey on Traceability System (TS) of hide in tanning industry, Bangladesh.

Welcome to the survey. This survey has been conducted for a study purpose to investigate the challenges for implementation of traceability system in tanning industry based on your valuable views on the present condition, drivers, motivation, and challenges to establish a traceability system (TS) of hide in tanning industry, Bangladesh. Your views will be collected through a set of questionnaires. It may take 3-5 minutes to complete the survey. Section 1 is about your personal and organizational information. The rest is regarding traceability system.

Your response will be processed on a computer and will be dealt with high confidentiality. Thank you for your participation.

Section 1: Personal and Organizational information

Name of your Organization:.....

Your e-mail address:.....

Your contact Number:.....

Your position in the Organization: Please put check (✓) mark in your answer box.

☐ Owner ☐ Manager ☐ Compliance Officer ☐ Other

Your years of Experience:

☐ Less than 1 Yr. ☐ 1 to 3 Yrs. ☐ 3 to 5 Yrs. ☐ More than 5 Yrs.

Your level of education:

☐ Under graduate ☐ Graduate ☐ Postgraudate ☐ Other

Your field of education:

☐ General ☐ Technical ☐ Business ☐ Other

Section 2: Perceived challenges for implementation of traceability system

		Strongly disagree	Disagree	Undecided	Agree	Strongly agree
1	The owners of the leather industry are not financially capable of investing for traceability system in this industry	☐	☐	☐	☐	☐
2	The industry needs financial incentives from Government and buyers to establish traceability system	☐	☐	☐	☐	☐
3	The return from the new investment to establish traceability system will be very high	☐	☐	☐	☐	☐
4	Establishment of traceability system requires huge investment	☐	☐	☐	☐	☐
5	Financial capability is not the key challenge to establish traceability of hide in tanning industry	☐	☐	☐	☐	☐
6	Technology is not the main challenge to establish traceability system in Bangladesh	☐	☐	☐	☐	☐
7	At present, machineries and equipment required to establish traceability are not readily available in Bangladesh	☐	☐	☐	☐	☐

8	Now, we have not enough technological capability to establish traceability system	Strongly disagree ☐	Disagree ☐	Undecided ☐	Agree ☐	Strongly agree ☐
9	There is lack of easy technological solution to implement traceability system in leather industry all over the world	Strongly disagree ☐	Disagree ☐	Undecided ☐	Agree ☐	Strongly agree ☐
10	There is no concrete Act, rules, and guidelines from governments side that can be enforced to established traceability system	Strongly disagree ☐	Disagree ☐	Undecided ☐	Agree ☐	Strongly agree ☐
11	Still no unified action plan has put in place including all stakeholder to establish traceability system in this sector	Strongly disagree ☐	Disagree ☐	Undecided ☐	Agree ☐	Strongly agree ☐
12	There is lack of coordination exists among the stakeholders e.g., government, owners, and suppliers to establish traceability system	Strongly disagree ☐	Disagree ☐	Undecided ☐	Agree ☐	Strongly agree ☐
13	All actors in the supply chain cannot equally realize the importance of establish traceability system in Bangladesh	Strongly disagree ☐	Disagree ☐	Undecided ☐	Agree ☐	Strongly agree ☐
14	Presently buyers are not highly concerned about the traceability of our product	Strongly disagree ☐	Disagree ☐	Undecided ☐	Agree ☐	Strongly agree ☐
15	The root level actors of the supply chain e.g., farmers, butchers and raw hide suppliers are completely	Strongly disagree	Disagree	Undecided	Agree	Strongly agree

	ignorant about the traceability of hide	☐	☐	☐	☐	☐
16	Absence of slaughterhouse in Bangladesh is one of the key challenges to establish traceability of hide as a requirement of international standard	Strongly disagree ☐	Disagree ☐	Undecided ☐	Agree ☐	Strongly agree ☐
17	Fruitful awareness program must be taken immediately to make fully aware of all the key stakeholder in this sector	Strongly disagree ☐	Disagree ☐	Undecided ☐	Agree ☐	Strongly agree ☐
18	Too many intermediaries in the supply chain have made the chain more complex	Strongly disagree ☐	Disagree ☐	Undecided ☐	Agree ☐	Strongly agree ☐
19	There is huge shortage of knowledgeable and skilled manpower in this sector to establish traceability system	Strongly disagree ☐	Disagree ☐	Undecided ☐	Agree ☐	Strongly agree ☐
20	The tannery owners are not highly motivated to establish traceability system	Strongly disagree ☐	Disagree ☐	Undecided ☐	Agree ☐	Strongly agree ☐
21	More study and research are highly necessary to find out a sustainable solution to establish traceability system in leather sector in Bangladesh	Strongly disagree ☐	Disagree ☐	Undecided ☐	Agree ☐	Strongly agree ☐

Thank you very much for your participation in the survey!

Appendix B: Benefit calculation for CBA

Let a tannery whose annual volume of export is 4,00,000 sq.ft , production cost $ 1.0 per sq.ft and selling price $ 1.1 per sq.ft before getting the compliance certification. After compliance certification the production cost will increase by (20%- 25%) and selling price will increase by 40% of previous selling price (Source: Asia Foundation: 2022 and KIIs). Let the production cost increase by 24%, therefore, per unit production cost and selling price will become $ 1.24, $ 1.54 respectively.

The potential contribution of traceability system on the overall benefit can be segregated according to the scoring ratio of traceability on overall score of audit protocol. In LWG audit protocol the overall score is 1710 whereas the contribution of traceability is 110. If a tannery ensures regional traceability (the minimum level), it will get 30% score that is 33 out of 110. Hence, the minimum contribution of traceability score on the overall score is 1.92%.

Before compliance	**Annual volume of export (Sq.ft)**	**Production cost per Sq.ft (USD)**	**Selling price per Sq.ft (USD)**	**Production cost (USD)**	**Selling price (USD)**	**Profit (USD)**
	4,00,000.00	1.0	1.1	4,00,000.00	4,40,000.00	40,000.00
After compliance	**Annual volume of export (Sq.ft)**	**Production cost per Sq.ft (USD)**	**Selling price per Sq.ft (USD)**	**Production cost (USD)**	**Selling price (USD)**	**Profit (USD)**
	4,00,000.00	1.24	1.54	4,96,000.00	6,16,000.00	1,20,000.00

Contribution of traceability is 1.92% of USD 1,20,000.00= USD 2304

Appendix C: SPSS output

Mean and Standard deviation of 21 variables:

```
DESCRIPTIVES VARIABLES=S1 S2 S3 S4 S5 S6 S7 S8 S9 S10 S11 S12 S13 S14 S15 S16
S17 S18 S19 S20 S21
  /STATISTICS=MEAN STDDEV SEMEAN
  /SORT=MEAN (D).
```

Descriptives

Descriptive Statistics

	N	Mean		Std. Deviation
	Statistic	Statistic	Std. Error	Statistic
S19	84	4.42	.054	.496
S16	84	4.40	.064	.583
S20	84	4.35	.064	.591
S10	84	4.26	.059	.540
S18	84	4.14	.076	.697
S21	84	4.10	.079	.722
S15	84	4.04	.084	.768
S6	84	4.04	.084	.768
S7	84	4.01	.089	.814
S12	84	4.01	.090	.829
S1	84	3.94	.084	.766
S13	84	3.88	.096	.884
S2	84	3.86	.080	.730
S11	84	3.70	.098	.902
S14	84	3.49	.080	.736
S4	84	3.40	.083	.762
S5	84	3.31	.103	.944
S8	84	3.08	.126	1.153
S3	84	2.40	.099	.907
S17	84	2.35	.075	.685
S9	84	2.04	.057	.525
Valid N (listwise)	84			

Reliability test of the survey data: Cronbach alfa:

```
RELIABILITY
  /VARIABLES=S1 S2 S3 S4 S5 S6 S7 S8 S9 S10 S11 S12 S13 S14 S15 S16 S17 S18 S19 S20 S21
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA.
```

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	84	100.0
	Excluded[a]	0	.0
	Total	84	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.770	21

Factor analysis:

```
FACTOR
  /VARIABLES S2 S3 S5 S6 S7 S8 S9 S11 S12 S13 S14 S17 S19 S20 S21 S22
  /MISSING LISTWISE
  /ANALYSIS S2 S3 S5 S6 S7 S8 S9 S11 S12 S13 S14 S17 S19 S20 S21 S22
  /PRINT INITIAL KMO EXTRACTION ROTATION
  /FORMAT BLANK(.4)
  /PLOT EIGEN
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25)
  /ROTATION VARIMAX
  /METHOD=CORRELATION.
```

Factor Analysis

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.748
Bartlett's Test of Sphericity	Approx. Chi-Square	651.143
	df	120
	Sig.	.000

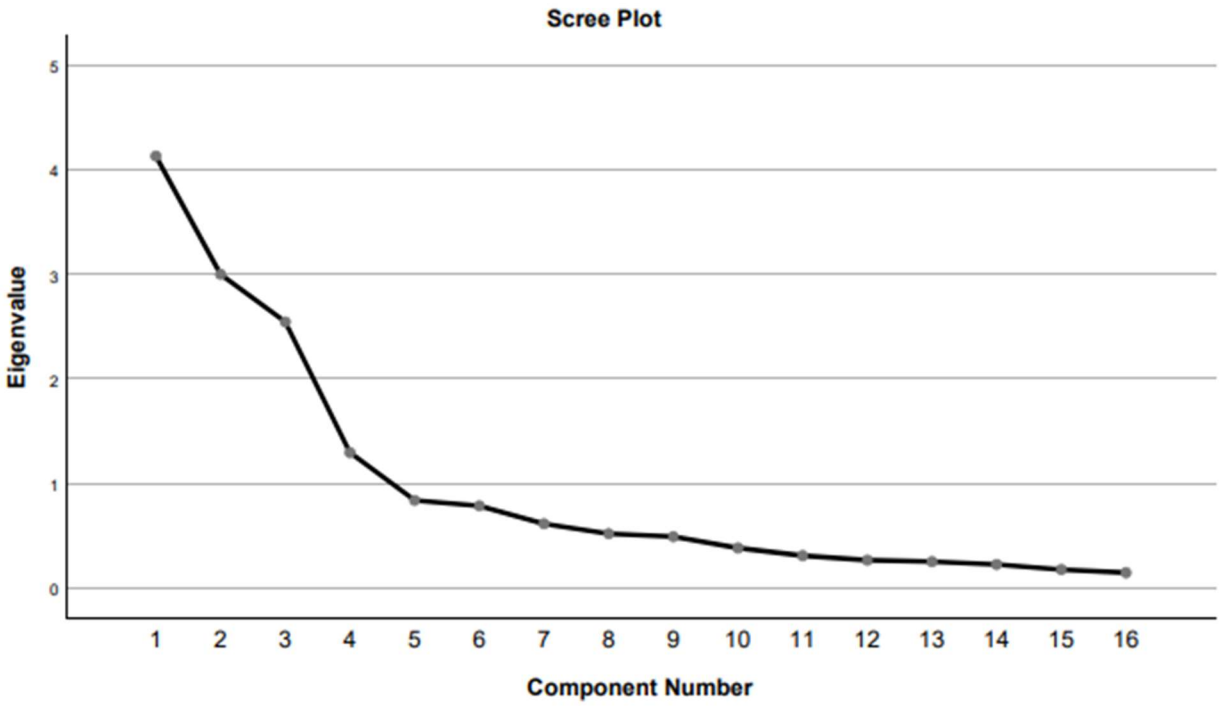
Communalities

	Initial	Extraction
S1	1.000	.839
S2	1.000	.785
S4	1.000	.766
S5	1.000	.638
S6	1.000	.701
S7	1.000	.825
S8	1.000	.788
S10	1.000	.743
S11	1.000	.703
S12	1.000	.715
S13	1.000	.525
S16	1.000	.710
S18	1.000	.610
S19	1.000	.598
S20	1.000	.537
S21	1.000	.521

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.131	25.817	25.817	4.131	25.817	25.817
2	3.000	18.753	44.569	3.000	18.753	44.569
3	2.546	15.913	60.482	2.546	15.913	60.482
4	1.297	8.104	68.586	1.297	8.104	68.586
5	.840	5.251	73.837			
6	.787	4.916	78.754			
7	.615	3.845	82.599			
8	.521	3.254	85.853			
9	.493	3.081	88.934			
10	.384	2.402	91.336			
11	.311	1.943	93.279			
12	.268	1.675	94.954			
13	.253	1.583	96.537			
14	.227	1.416	97.953			
15	.179	1.117	99.070			
16	.149	.930	100.000			


Scree Plot
Eigenvalue
0
1
2
3
4
5
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Component Number

Rotated Component Matrix[a]

	Component			
	1	2	3	4
S1		.906		
S2		.884		
S4		.857		
S5		.789		
S6			.765	
S7			.905	
S8			.835	
S10				.818
S11				.817
S12				.733
S13	.659			
S16	.819			
S18	.711			
S19	.757			
S20	.706			
S21	.538			

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations.