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Feasibility Study of Leather Solid Byproduct Transformation into Valuable Products for MSMEs and Tanneries in Modjo and Around Modjo Area, Ethiopia.

Client:
SOLIDARIDAD ETHIOPIA

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Acronyms and Abbreviations

LLPI-RDC –Leather and Leather Products Industry Research and Development Center
LISEC - Leather Initiative for Sustainable Employment Creation in Ethiopia
GDP – Gross Domestic Product
UNIDO - United Nations Industrial Development Organization
EPA- Environmental Protection Authorities
FDRE- Federal Democratic Republic of Ethiopia
GTP- Growth and Transformation Plan
ELIA- Ethiopian Leather Industries Association
EIC- Ethiopia Investment Commission
MoI- Ministry of Industry
DBE- Development Bank of Ethiopia
CBE- Commercial Bank of Ethiopia
EIA- Environmental Impact Assessment
PPE- Personal Protective Equipment
OHS- Occupational Health and Safety
ETP- Effluent Treatment Plant

Acknowledgment

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Abstract

In Ethiopia, there are about 34 registered tanneries and an average of 20 million skins and 2 million hides are consumed by the leather industries every year. The leather industry in Ethiopia is one of the top growing economic sectors and is set in the front position by the Ethiopian government. However, Tanneries are generally pollution-intensive industrial complexes generating large volumes and high concentrations of liquid and solid bi-products from tanneries impacting the nearby environment immensely. In this regard, the tanneries are characterized by generating a huge amount of not only solid waste; but also, a high concentration of chromium, sulfides, suspended solids, and dissolved solids. Moreover, hide scraps, skins, salt, and excess fats are also some of the waste emanating from the industries. Consequently, the tanneries are also sources of controversy and anger among city residents and the surrounding kebeles as they are major sources of pollution that significantly affects the environment of the town and surrounding local villages. Some of the huge quantities of solid bi-products from tanneries produced from various operations of tanneries are put to practical use, but the majority of the wastes is dumped without any effective usage and becomes a source of pollution. The lack of waste-to-wealth approaches and secured landfill is making the segregation and disposal of tannery solid waste much more difficult.

It is with this context that the LISEC project came into effect funded by the European Union and three implementing agencies *(People in Need, International Rescue Committee, and Solidaridad)*. The project aims to strengthen social cohesion by supporting local economies and social development initiatives, especially for women and youth living in Modjo areas; and enhancing industrial and labor relations in Modjo Leather City.

The main objective of this assignment is to perform a detailed technical, financial, market study, and market linkage assessment for Leather Solid Waste Transformation Businesses of upcoming MSMEs and Tanneries in Modjo and Around Modjo Area, Ethiopia. The assessment primarily based on the studies conducted by LLPIRDC, which

includes: ‘Utilization of de-dust salt from raw hide/skin during the pickling process’, ‘Preparation, characterization, and application of protein hydrolysate from chrome-bearing solid bi-products from tanneries’, ‘Preparation of leather board from chrome shavings’, ‘Production of glue from hide limed trimmings’, ‘Preparation of organic compost from tannery fleshing waste’ and ‘Brick production from tannery effluent sludge and clay’.

The assessment framework considered the following seven criteria in evaluating the feasibility of the six projects: waste supply and availability, technical and logistics, institutions, regulations, and investment climate, market assessment, financial assessment, environment, occupational health and safety risk, and impact Assessment and socio-economic impact assessment. In the study, data were collected from various stakeholders such as LLPIRDC, and tanneries around Modjo and Addis Ababa area, the municipality of Modjo town. In addition, existing business owners in the area of leather processing bi-product valorization, and relevant stakeholders have also been considered.

The result of the assessment shows that of the six proposed projects by LLPIRDC, three are feasible considering all the seven criteria outlined in the assessment criteria above. These projects are: Utilization of de-dust salt from raw hide/skin during the pickling process, Preparation of application of protein hydrolysate from chrome-bearing solid bi-products from tanneries and Production of glue from hide limed trimmings. These projects have resulted in a net present value (NPV) of 5,402,941.27 ETB, 81,902,364 ETB and 25,623,430 ETB respectively and an annual overall disposable waste reduction of 928 tons. Moreover, the three projects have been found to generate a collective job opportunity for about 50-65 job seekers. Moreover, the projects would also enable foreign currency saving from reduced import of the final products, and reducing the disposal cost of toxic waste. In addition, the projects would also improve public health and also bring positive impacts in instilling improved waste disposal practices with positive contributions to regulatory change/amendments for better law enforcement.

For the other three projects, however, i.e. Preparation of leather board from chrome shavings, preparation of organic compost from tannery fleshing waste, and brick production from tannery effluent sludge and clay, the assessment concerning the first two criteria; i.e. waste supply and availability, technical and logistics requirements were found

to not be viable, considering the importance of these criteria in ensuring the competitiveness of the businesses.

Considering the holistic impact of valorization from leather wastes to the Modjo area, the municipality's role will be rudimental for the successful realization of the projects. Some of the expected support may include: the provision of land, facilitation of access to finance through the micro-financing institutions present locally and capacity development support.

Introduction

In Ethiopia, there are about 34 registered tanneries and an average of 20 million skins and 2 million hides are consumed by the leather industries every year (LLPIRDC 2020). According to the Ethiopian investment commission, Ethiopia has the largest livestock population in Africa, measured at around 53 million cattle and it is the 10th largest producer in the world. Unfortunately, only 50 % of the hide and skin potential is currently being utilized. According to the report by LLPIRDC,2020, the leather sector contributes on average 6-8 % of the gross value product of all manufacturing industries and contributes about 6 percent to the national GDP. The Export of leather, which was 23 million USD in 2013, reached 133 million USD in 2018 (Leather International 2021). According to the Ethiopian Investment Commission (EIC), the leather sector is one of the country's leading manufacturing sectors. According to the report by United Nations Industrial Development Organization (UNIDO 2020), Ethiopia's leather and leather products sector produces a range of products from semi-processed leather in various forms, including shoes' upper parts, leather garments, stitched upholstery, backpacks, purses, industrial gloves and finished leather. Even though the leather industry contributes, a lot to Ethiopia's economic development pollution problem of Tannery wastes is affecting the nearby environment immensely. The tanneries are creating potentially toxic wastewater, tanneries also produce a huge amount of solid waste, high concentration of chromium, sulfides, suspended solids and dissolved solids, hide scraps, skins, slat and excess fats.

1.1. Overview of Impact of Leather Waste

During the process of leather processing, substantial amounts of solid and liquid bi-products are generated. The various solid bi-products generated from tanneries are hair, wool, raw trimming and fleshing, wet blue shavings and splits, crust trimmings, buffing dust, and sludge. Some of the huge quantities of solid bi-products from tanneries produced from various operations of tanneries are put to practical use, but most of the wastes are dumped without any effective usage and become a source of pollution. Therefore, the disposal of these wastes becomes a severe problem for the world tanning industry (Fathima, Rao, and Nair 2012). (Silva 2021) highlighted that the tannery industry is considered as one of the industries with a significant environmental impact. Leather

industry waste can be a valuable resource (Ngoc and Schnitzer 2009). For processing, one metric ton of rawhide, 200 kg of tanned leather, 200–250 kg of tanned leather waste, 190–350 kg of untanned waste, and 50,000 kg of wastewater is produced as shown in figure 1 which means just 20% of the raw material becomes finished leather (Monteiro De Aquim, Gutterres, and Trierweiler 2010).

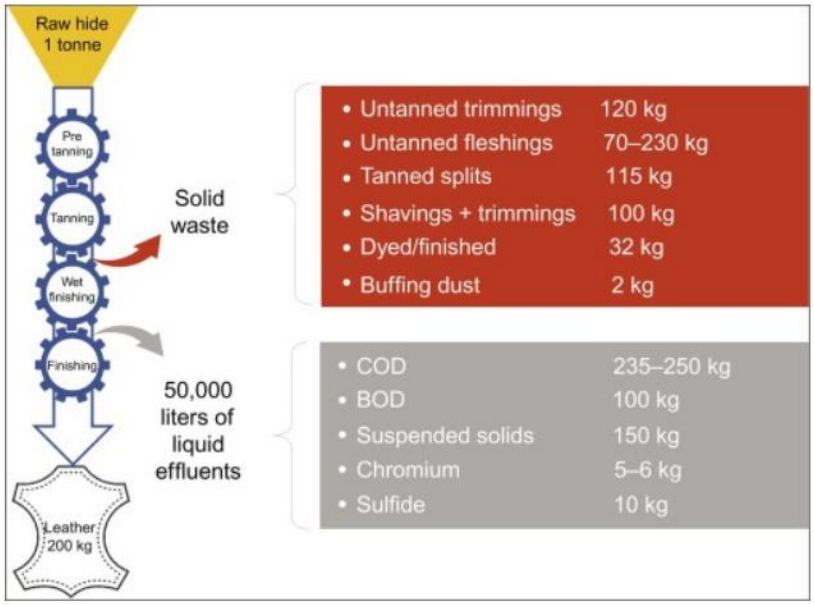

Figure 1: Environmental impact of leather processing (Chakraborty 2003)

Solid bi-products from tanneries are unavoidable and the solid bi-products from tanneries generated during the production of leather can be classified as follows: Wastes from untanned skin/hides (e.g., trimmings and fleshing wastes), Wastes from tanned leather (e.g., shaving wastes and buffing dust) and Wastes from dyed and finished leather (e.g. trimmings). Research. Apart from the fact that leather degrades slowly, treating it with various chemicals in the process of tanning makes it more rigid and resistant to chemical, thermal, and microbial degradation (Fathima, Rao, and Nair 2012; Silva 2021).

1.2. Leather Waste Management Practices in Ethiopia

The leather industry in Ethiopia is one of the top growing economic sectors and is set in the front position by the Ethiopian government. However, Tanneries are generally pollution-intensive industrial complexes generating large volumes and high concentrations of liquid and solid bi-products from tanneries.

Tannery solid waste represents one of the burdensome environmental problems owing to the large quantities of discarded material. Tanneries in Ethiopia as a general, are characterized by their unpleasant smell and polluting behaviors which is due to uncontrolled and desegregated disposal of tannery solid waste (LLPIRDC 2020). The lack of waste-to-wealth approaches and secured landfill makes the segregation and disposal of tannery solid waste much more difficult. Segregation must be performed by separating various solid bi-products from tanneries based on their property. Tannery wastes have historically been discharged into rivers, landfill waste sites and the air with little if any purification. Even though it is evident that improper management of the waste from the tanning industry is full of risk to human and environmental health, presently almost all of the leftovers from leather product industries in Ethiopia and elsewhere are sent to the land as waste.

According to the study by Teklay et al.(Teklay et al. 2017), improper management of the tannery industry waste is full of risk to the human that is living the vicinity of the industry and creates environmental health. The leather industry generates considerable amounts of solid, liquid, and gaseous wastes.

1.3. LISEC Project and SOLIDARIDAD's Work Component

The LISEC project aims to strengthen social cohesion by supporting local economies and social development initiatives, especially for women and youth living in Modjo areas; and enhancing industrial and labor relations in the Modjo Leather City. In this project, SOLIDARIDAD is responsible for coordinating the technical study component of the work. In this regard, Leather and Leather Product Industry Research Development Center (LLPIRDC) conducted six technical studies on the utilization of solid bi-products from

tanneries into a valuable product to create a decent job for unemployed women and youth in Mojo and its surrounding. The six technical study summary is here below.

1.3.1. Utilization of De-dusted Salt from Raw Hide/Skin for the Pickling Process

Wet salting is one of the mostly used hide and skin curing practices in the world. The reason for this can be that salt price is not only cheap but also widely available. Moreover, it has good dehydrating properties. Then, curing salt is removed during soaking and discharged in waste soak streams. The salt discharged in the soaked liquor increases the total dissolved solids content of groundwater and surface water. International trends show that excess salt can be removed from the wet salted hide/skin before soaking and reused for pickling operations after clarification. Solomon (2021) highlighted the quantity of salt removed varies with the method employed for desalting. In this regard, salt removal by mechanical desalting using perforated drums is 5 % of the weight of raw stock; with manual desalting using Dodeca and desalting by brush-type machine, it can reach up to 7 – 8 % of the weight of raw stock desalted.

1.3.2. Preparation, characterization, and application of protein hydrolysate from chrome-bearing solid bi-products from tanneries

Chrome shavings are one of the major solid bi-products from tanneries generated during the leather-making process. The presence of chromium in waste creates difficulty in disposing of landfills and incineration. Growing environmental concern about the toxicity and environmental impact of the chromium solid bi-products from tanneries generated from the tannery has become a key issue (Pati, Chaudhary, and Subramani 2013). Chrome shaving also contains a rich amount of collagen protein. Protein or collagen hydrolysate can be extracted from this polluting solid bi-products from tanneries (chrome shavings) by biochemical hydrolysis process, and other methods.

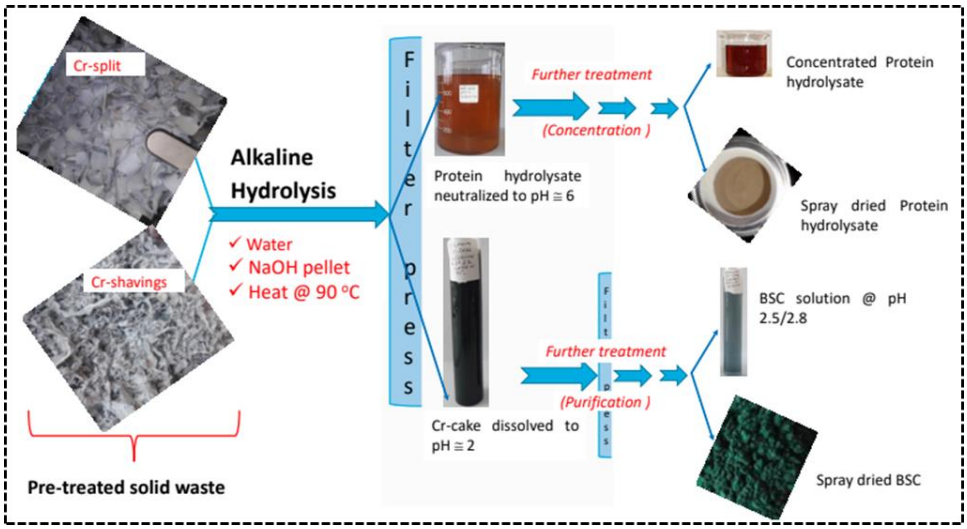

Figure 2: Protein hydrolysate preparation processes

1.3.3. Preparation of organic compost from tannery fleshing waste

Limed fleshing is one of the major proteinaceous solid bi-products from tanneries which is produced in fleshing operations and tanneries. The generated fleshing is usually kept indiscriminately inside or outside of the industrial area, which causes environmental pollution. Composting has been used for the utilization of limed fleshing and it is a better option for solid bi-products from tanneries management especially organic solid bi-products from tanneries than all other options (Ghosh et al. 2020). Various microorganisms break down organic matter into simpler nutrient-rich products, which are used as fertilizer. It is much better than chemical fertilizer because it is not associated with any kind of risk.

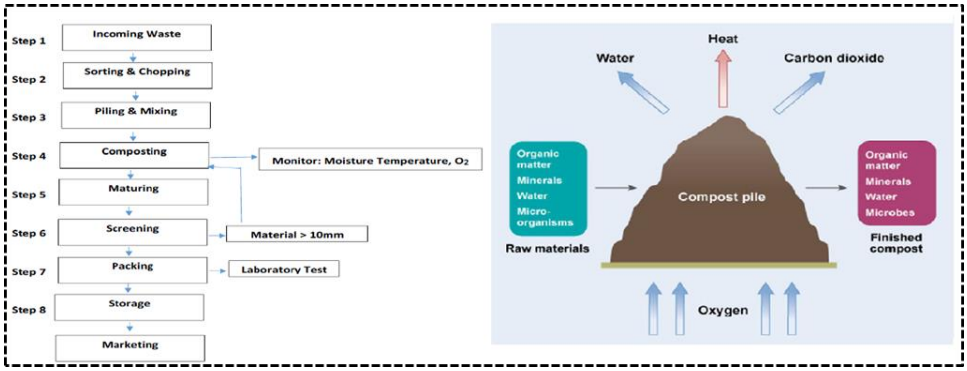

Figure 3 : Composting Process

1.3.4. Production of glue from hide-limed trimmings

Animal glue is the most important protein adhesive obtained from animal hides, skins, and bones through hydrolysis of the collagen (Negash G et al. 2019). Animal hides are soaked in water to produce "stock." The stock is then treated with lime to break down the hides. The hides are then rinsed to remove the lime, any residue being neutralized with a strong acid solution. The hides are heated, in water, to a carefully controlled temperature of around 70 °C. The "glue liquor" is then drawn off, more water added, and the process repeated at increasing temperatures.

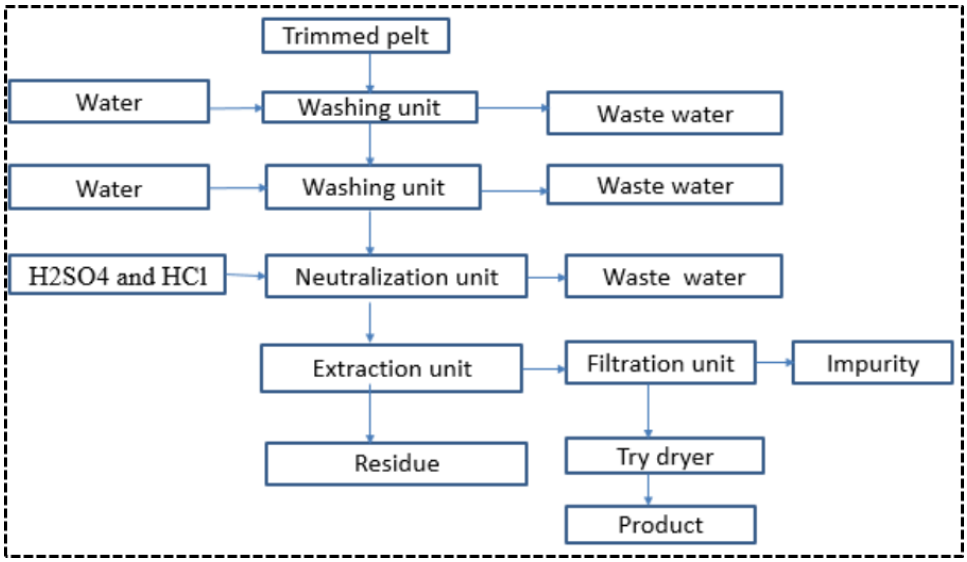

Figure 4 : Process diagram of glue production from tannery solid bi-products from tanneries

1.3.5. Preparation of Leather Board from Chrome Shavings

Preparation of leather boards from chrome shavings waste is economical and helps in reducing the environmental pollution. The process for the preparation of leather boards involves soaking chrome shavings in mild alkali, processing in a mincer, and mixer addition of rubber latex and other chemical required and diluted to 5 % with water and passing through a nylon mesh and applying vacuum to get wet leather board. These wet boards are pressed in a hydraulic press to remove excess water and dried to get leather boards. These boards are later calendared and stored. These boards are ready for use. The unique feature is that the process provides an eco-friendly as well as economical

option to utilize tannery chrome shavings, which would otherwise add to disposal problems, into a value-added product, thereby creating value addition and utility for a byproduct of the tannery.

1.3.6. Brick Production from Tannery Effluent Sludge and Clay

Tannery solid bi-products from tanneries represent one of the burdensome environmental problems owing to the enormous quantities of discarded material besides the toxicity of the sludge. Chromium-rich tannery sludge (TS) generated from the effluent treatment plants of the leather industry has the potential to contaminate soil, surface water, and groundwater and pose a threat to the environment and natural resources if it is not disposed of properly. Usually, about 100 - 150 kg of sludge is generated per ton of hides/skins processed which is composed mostly of chemically precipitated dissolved chromium, several types of spent chemicals, sulfide, salt, proteins, polyphenolic compounds, surfactants, dyes and syntans in the treatment process. Several studies have shown that tannery sludge can be effectively stabilized in construction materials such as concrete, ceramic tiles, and other engineering materials.

2. Objectives

2.1. Overall Objectives

The main objective of this study is to conduct a feasibility study for six technical studies conducted by LLPIRDC on the utilization of tannery solid bi-products from tanneries into a valuable product to create a decent job for unemployed women and youth in Mojo and its surrounding.

2.2. Specific Objectives

The specific objectives of the assignment are:

- To perform technical feasibility (aiming to answer the following questions)
    - Are they easy for operation by unemployed youth and women with a minimum academic background?
    - Are they environmentally friendly?
    - Are they socially acceptable?

- To perform financial feasibility (aiming to answer the following question)
    - Are these initiatives financially feasible and could they be initiated with minimum capital?
- To study market linkage opportunities (aiming to answer the following questions)
    - Do these initiatives have a sustainable market?
    - Are the initiatives best fit for Micro, Small, and Medium Enterprises modality or tanneries?

3. Scope of the Assignment

- The Geographic location for this study is Modjo and its surrounding
- Preliminary technical studies conducted by Leather and Leather Product Industry Research Development Center (LLPIRDC) have to be incorporated in the study to be developed as a major source of data. The six studies conducted by LLPIRDC are:
    - Utilization of de-dust salt from raw hide/skin during the pickling process
    - Preparation, characterization, and application of protein hydrolysate from chrome-bearing solid bi-products from tanneries
    - Preparation of organic compost from tannery fleshing waste
    - Production of glue from hide-limed trimmings
    - Preparation of leather board from chrome shavings
    - Brick production from tannery effluent sludge and clay
- The consulting firm will collaborate with the lead researchers of LLPIRDC to undertake the six technical studies and produce a feasibility study for each six technical studies

4. Methodology

4.1 Overall Methodological Approach

This study adopted a consultative and participatory approach to ensure that stakeholders must be engaged at all stages of the work. Both qualitative and quantitative methods have been adopted while doing this assignment. The following are some of the generic major activities that were incorporated into the methodology.

a) **Stakeholders Mapping and Analysis**: Stakeholders mapping and analysis were used for this assignment to identify institutions, individuals, groups, or organizations that have related knowledge and experience on tanneries and tannery waste management. The stakeholder analysis helped us to figure out which organizations, groups, and individuals we are going to involve in this assignment while collecting data.
b) **Focus Group Discussion and Key Informant Interviews**: Focus group discussions were made with several tanneries, LLPIRDC experts, and government agencies. Moreover, in-depth interviews with experts who have been working in leather Areas for several years were conducted.
c) **Data collection**: Primary data were collected using selected sites field surveys, checklists, questionnaires, interviews, observation, etc. Besides, secondary data were also collected from various sources. The six research outputs conducted by LLPIRDC were received
d) **Interview with Researchers:** To get firsthand information, selected researchers and scientists who have been working on the six projects were interviewed.
e) **Analysis:** Both the qualitative and quantitative information gathered were analyzed using the appropriate tools and methodologies
f) **Reporting:** Both the progress milestones and the final deliverables of the project were reported to the project owner using appropriate methodologies throughout the project lifecycle.

4.2 Multi-Criteria Assessment Conceptual Framework

To capture the different dimensions of the feasibility study, a multicriteria analysis (MCA) offers an appropriate framework to provide decision-makers with a full range of social, environmental, technical, economic, and financial information. Thus, the following seven criteria for the MCA framework were used in the feasibility assessment of the proposed waste converting businesses.

Each criterion has its own set of indicators, with these indicators having a set of research questions and to address these research questions, a specific approach/ methodology

was applied. The table below illustrates MCA framework(criteria) and corresponding indicators.

Table 1: MCA Framework for the feasibility study

S.N	Criteria	Indicators
1	Waste supply and availability	○ Waste supply and Availability ○ Reliability of resource supply ○ Competitors' index for waste resource
2	Institutions, regulations and investment climate	○ Structure and capacity of institutions ○ Policy and legal Framework support ○ Level of budgetary and other issues ○ Community support
3	Market assessment	○ Product Quality ○ Price competitiveness
4	Technical and logistical assessment	○ Availability/suitability of the processes/ technologies ○ Technology (resource) requirements index (spare parts, other production factors) ○ Performance and efficiency of process/technology ○ Operation and maintenance (O&M) requirements
5	Financial analysis	○ Net Present Value (NPV) & Internal Rate of Return (IRR) ○ Income Statement & Balance Sheet ○ Response to sensitivity changes
6	Health and environmental risk and impact assessment	○ Work-related risks Environment and OHS ○ Risk reduction strategies in place ○ Estimated emissions (solids fluids and gas) to waterbodies soil and air
7	Socio-economic impact assessment	○ Socio-economic benefit/cost ○ Environmental and health benefit /cost

Note that: The details of the questionnaires/checklist, and interview questions used to assess each criterion/indicator are attached in the appendix section of this report.

4.3 Methods of Data Collection and Potential Stakeholders Concerned

The following are the data collection methodologies deployed and stakeholders communicated/consulted during the feasibility study

Data collection methods/tools	Potential stakeholders concerned
○ Review of literature and national and international laws/regulations, case studies, etc ○ Use of questionnaires ○ On-site factory visit (4 tannery factories*) ○ Observation/interview (existing businesses, tannery factories)	○ Environmental Protection Authority ○ Ministry of Industry (MoI) ○ Existing waste valorization businesses (glue producer, brick factory

○ Interview of relevant institutions e.g EPA, LLPIRDC /MoI, etc ○ Review of secondary data ○ Analyzing process flow diagram ○ Consultative meeting/discussion with LLPIRDC experts (more than 15 times- both formal and informal ○ Expert judgment	○ Modjo town Municipality (Visited one time) ○ Banks e.g developmental bank ○ Central Statistics Agency

*The 4 tannery factories visited are: Batu, Ethiopia, George shoe and Colba tannery
Note that: Purposive sampling technique was applied for data collection from tanneries based on their willingness.

5. Presentation of Feasibility Studies

5.1. Project 1: Production of Glue from Hide-limed Trimmings

Animal glue is the most important protein adhesive obtained from animal hides, skins, and bones through hydrolysis of the collagen (Negash G et al. 2019). Animal hides are washed in water to produce "stock." The stock is then treated with lime to open the hides. The hides are then rinsed to remove the lime, any residue being neutralized with a strong acid solution. The hides are heated, in water, to a carefully controlled temperature of around 70 °C/80ºC. The "glue liquor" is then drawn off, more water added, and the process repeated at increasing temperatures. The tanning industry is categorized as one of the potentially pollution-intensive industries. Tannery generates a huge amount of solid bi-products from tanneries as follows: fleshing, 50–60; chrome shaving, chrome splits and buffing dust 35–40 %; skin trimmings, 5–7; and hair, 2–5%. solid bi-products from tanneries in leather processing constitute beam house, 80; tanning, 19; finishing, 1% (Shaikh et al. 2017).

In leather processing, from every 1000 kg of raw hide/skin only 250-200kg of the raw material is converted into leather and nearly 700-750 kg is generated as solid bi-products from tanneries (Kanagaraj et al. 2006). Most of the solid bi-products from tanneries are generated in beamhouse operations, especially in fleshing operations (Kanagaraj et al. 2006). From the raw hides and skins, 25-30% of it is converted into final leather remaining 70-75% of it is removed as solid bi-products from tanneries. Of the total tannery wastes,

54-60% is the fleshing/trimming waste. 8-10 kg/hide per piece or an average of 0.375 kg /kg of fleshing/trimming solid bi-products from tanneries is released. These solid bi-products from tanneries can be converted into valuable products like glue, gelatin, protein filler, fertilizer, etc.

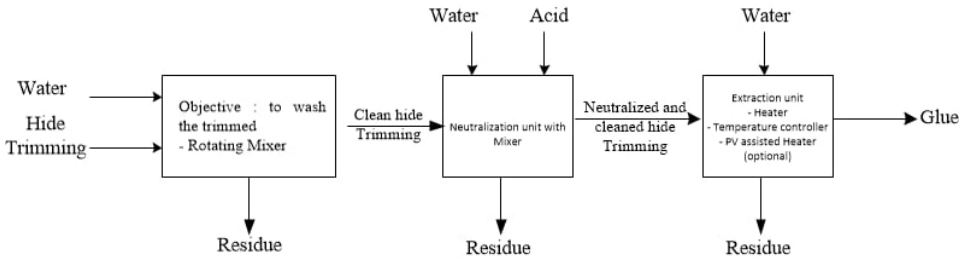

Figure 5 : Glue Production process

5.1.1. Waste Supply and Availability

a) Sources, Quantity, And Quality of Generated Waste

Glue can be produced from limed trimming raw trimming, fleshing and untanned splits can also be other inputs for glue production from hides. Fleshing/trimming waste accounts for 54-60% of solid bi-products from tanneries generated from the tannery industry (Bethelhem 2018).

Hide limed trimming waste is generated when a rough edge is cut off after fleshing process (Green World Consult 2012). The physical and chemical characteristics of limed skin and hide trimmings are: Slippery to touch, Turgid, Brownish black, Alkaline due to the presence of lime (calcium oxide), pH 12-13.

The rate of generation of hide-limed trimming in the study area (Modjo town) is calculated based on the following basic data.

Table 1: Rate of generation of hide-limed trimming in the study area

S. N	Description	Response	Remark/Reference
1	Currently operating number of tannery factories around Modjo	12	
2	Number of working days/years	280	

3	Average actual production or soaking capacity (pieces/year)		Calculated from the production data of the 12 tannery factories in the past 10 years (2004- 2013 EC)- LLPIRDC
	Hide	1,039,717	
	Skin	10,407,595	
4	Hide limed trimming Generation rate		Source*1
	Average hides limed trimming (Kg/pc)	4.5	
	Quantity of hide limed trimming (Kg/year)	4,678,726	
	Quantity of hide limed trimming (Kg/day)	16,710	

Source: LLPIRDC- Leather and Leather Products Industry Research and Development center

The trimming pelt should not be too dry due to excessive storage and should not form any signs of decay like bad smell and development of bacterial spores around the pelt which affects the quality of the raw material.

In addition to the hide limed trimmings, limed splits can be used as raw materials for glue production. Most of the time the splitting waste that is generated at the liming stage which is also called pelt splitting is considered a waste. According to Bethlehem, (2018), an average of 5Kg of limed splitting waste is generated per piece of hide. Thus, the rate of generation of limed splits is estimated to be 18,566Kg/day from tannery companies around Modjo town.

b) Reliability of Waste Supply

The quantity and quality of hide limed trimming cannot differ from season to season. The limed trimming is available every month as long as there is production. The range of quantity of limed trimmed pelt might increase or decrease based on the input quantity of raw hides and skins as well as the production plan. For instance, there will be a huge amount of raw hides and skins collected from abattoirs during holiday seasons in the Ethiopian context. Hence, the generation of the waste also varies accordingly. The seasonal fluctuation/variation rate of the waste generated is not well evaluated in Ethiopia.

Regarding its stability, trimming pelt should not be put in an open-air for not more than 2 hrs to prevent grain defect called lime blast. But putrefaction will not occur till a week

(LLPIRDC). Transportation of the trimming pelt does not require a special container. But the pelt is slippery, and hence cannot be handled easily.

c) Competitors' Index for Waste Resource

Hide limed trimming can be converted to varieties of valuable products. The table below illustrates the BATs options for limed trimming utilization (Black et al. 2013).

Table 2: Competitors' index for waste resource

S. N	Techniques	Options
1	Uses as a by-product	Collagen production
2	Reuse after preparation	Production of technical gelatin, tallow or protein hydrolysate
3	Recycling as	Hide glue
4	Other recovery	Generation of biogas by anaerobic digestion

In Ethiopia's case, the traditional glue producers are companies based in Ethiopia/Modjo that have been engaged in this business and collecting the input materials from the nearby tannery companies. Hence, they are competitors in this new business concerning the waste supply and availability. Moreover, the new emerging business – the gelatin production factory can also bring change to the supply and price of waste (hide limed trimming and limed splitting). Thus, the following intervention measures should be taken to alleviate the challenges related with raw material supply & availability and cost.

- Utilization of alternative sources of raw materials such as raw trimming, fleshing waste, etc by the bigger firms- gelatin production factory
- Source some part of the raw materials from the nearby city e.g Addis Ababa. But the logistic cost should be taken into account. There are around 34 tannery factories in Ethiopia. More than 6 operational tannery factories currently located in Addis Ababa can be the sources of the required raw materials.

- Smaller proportion of the raw material (not more than 10%) can be secured for the new glue production business (MSME) under stablished binding modality facilitated by the concerned bodies.

With the assumptions of further improvement in waste segregation and storage conditions at tanneries, presence of binding modality b/n tanneries and waste converting businesses, comprehensive support from the Modjo Town administration/LLPIRDC and expected increase in waste volume, there will be no significant risk of the proposed business regarding waste supply and reliability, quality and price. The current price for 1 kg of hide limed trimming is 4 ETB (LLPIRDC).

5.1.2. Technical and Logistical Assessment

a) General Description of The Whole Process

The basic processes used to make glue from hide or skin glue is as follows and shown in figure 8. The hides and skins are washed so that dirt is removed, and after washing they are soaked to soften them (Gillian S. Holmes 2020). This material is called stock, and it is passed through a series of water baths in which more and more lime is added to make the hides and skins swell and break them down. The swollen hides are rinsed in a large washing machine to remove the lime. The last traces of lime are eliminated by treating the stock with strong acids like Sulphuric or Hydrochloric acid. Finally, the hide is cooked either by boiling, in open tanks, or cooking under pressure in autoclaves. Extraction of the glue Cooking at the correct temperature and for the right length of time breaks down the collagen and converts it into glue. If the temperature or timing is off, the quality of the glue will be ruined. Large steam coils in the open tanks heat the water and product to (70°C 80^{o}C). Three or four treatments with clean water are performed at increasing temperatures (or pressures if a pressurized system is used). The resulting liquid, called "glue liquor" is extracted and reheated again to thicken or concentrate the glue.

When cooled, this material looks like jelly and is solid; although it looks like the kind of gelatin used in food, it contains impurities. To remove the impurities and make the glue clear, chemicals like alum or acid followed by egg albumin may be added. These chemicals cause the impurities to precipitate, or fall out, of the glue. Mechanical methods

can also be used to clean the glue. These include passing the glue through a series of mechanical filters or through paper filters or ground bone called bone char.

Different additives are mixed with the glue liquor to make brown, clear, or white glue. Sulfurous acid, phosphoric acid, or alum are among these additives. Zinc oxide is added to produce white glue

To this point, the glue is a weak, runny liquid. It is made more concentrated in vacuum evaporators and dried in one of several methods. The glue can be chilled into either sheets or blocks and then suspended on nets to dry and become still more concentrated. The glue can also be dropped as beads or "pearls" into a non-water bearing liquor that further dries the concentrated beads. The pearls, blocks, or sheets are then mixed to the right consistency and pumped into bottles or jars for sale.

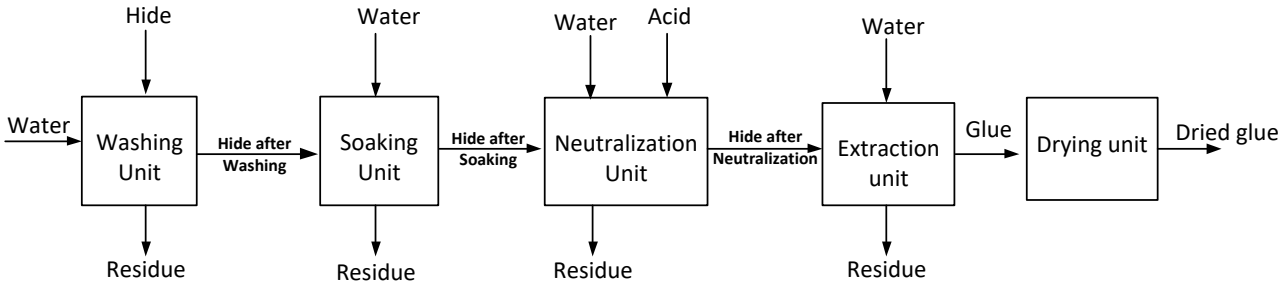

Figure 6 : Glue production process

One of the major issues in glue production is getting the constant heat required for glue extraction purposes. Thus, solar assisted i.e. photovoltaic-assisted heating system with a temperature controller is recommended. The energy extracted from solar energy is used for heating purposes and electric power for pumps. Besides, there is also a backup biomass-based heater for the extraction unit in case of no sunlight or during night operation. The washing, soaking, and extraction unit is also fitted with a manual mixer. After glue extraction, the moisture from the glue must be evaporated. Thus, a solar heating system is used. The system also has an evaporator drier using an electric-powered evaporator in case of urgency to dry the glue as shown in figure 9. Controlling the required parameters of the production process continuously and frequent laboratory test for the produced product will assure the product quality.

Figure 7 : Glue production system with Solar Heating and Biomass backup heater and solar glue drier

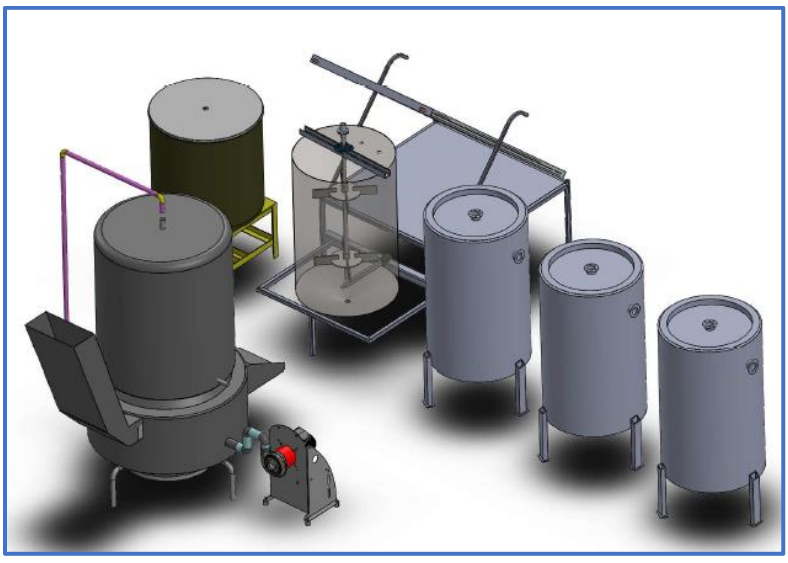

Figure 8 : Glue production system with Solar Heating and Biomass back up heater

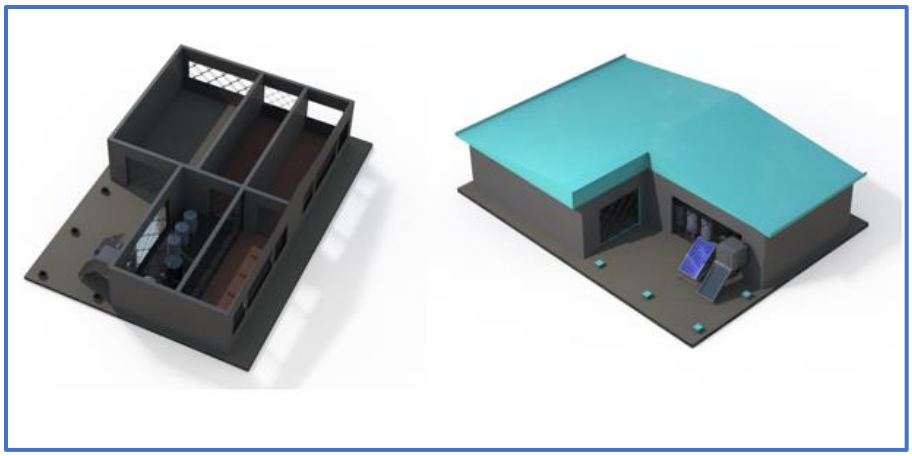

Figure 9 : Overall structure of the system Glue production system

b) Description of the Process Steps

5.1.2.a.1. Washing Unit

The hide is washed to remove dirt particles. To make the washing process effective, a manual or motor-driven agitator or mixer can be used. The water required for washing the hide is pumped using pumps. Thus, in our system, the washing unit is a cylindrical unit with an agitator. The water used for washing is pumped into the system.

5.1.2.a.2. Soaking Unit

After washing they are soaked to soften them. The hide glue stock is soaked in a saturated lime solution to soften and condition the glue stock. The soaking process is passed through a series of water baths in which more and more lime (7-10%) is added to make the hides and skins swell and open up. The swollen hides are rinsed in a large washing machine to remove the lime. Several water baths using agitated tanks and increasing amounts of lime make the hides/skins swell and open up.

5.1.2.a.3. Neutralization unit

The last traces of lime are eliminated by treating the stock with strong acids like sulphuric or hydrochloric acid. The glue stock is then washed back to approximately a neutral pH value, or neutralized with an alkaline reagent.

5.1.2.a.4. Extraction unit

Cooking/boiling time and temperature are critical to the glue quality. Cooking at the correct temperature and for the right length of time breaks down the collagen and converts it into the glue. The conditioned, swollen, and neutralized glue stock is then extracted with hot water in a series of "cooks' at increasing temperatures to obtain the glue. Boiling at approximately 70°C/80°C is necessarily optimum for the production of commercially viable glue (Negash G et al. 2019).

5.1.2.a.5. Drying Unit

The glue is strengthened and concentrated in vacuum evaporators and then dried. Chilling and other processes may be used to further dry and concentrate the glue. Finally, the glue is mixed to the right consistency and pumped into bottles or jars for sale. Following cooking, heat is applied to the resulting liquid, called “glue liquor,” to thicken it. Chemicals are added to remove impurities and make the glue liquor clear. Mechanical methods including filters and ground bone may also be used to remove impurities. Additives are used to color the glue or keep it clear. Zinc oxide is added to produce white glue.

c) Description and Selection of Technology

Glue production from hide and skin has been used in various parts of the world and the techniques are very well known. However, innovative ideas must be introduced to improve the quality of glue produced and to reduce the amount of energy used and time of production. An additional system is also required to control the temperature of the glue extraction, adding the right amount and concentration of acid to neutralize the limed glue. Besides the business is intended for youths and women. Thus, the following selection criteria must be met while selecting and designing the overall system of glue production: Local manufacturability, ease of use, energy source, maturity of technology, cost, and efficiency of conversion.

Table 3: Selection of Technology

No	Items	Local availability	Easy to use	Energy source	Maturity of technology	Cost	Efficiency
1	Washing Unit with Manual Mixer	The system is manufactured locally	The system is being operated by any person with a simple hand on training	The system is operated manually to avoid electricity use	A pump and agitator is used for pumping the water to the washing unit and mixing the hide respectively	Low cost	high removal of dirt FROM hide
2	Soaking Unit	The system is manufactured locally and easily	Very easy to use	No electricity usage	Soaking of hide to soften the hide is a well-known technique.	Low cost	Effective soaking unit without damaging the hide
3	Neutralization unit	The system is manufactured locally and easily	Very easy to use and careful operational procedure to avoid acid contact	No electricity usage	The technology is very simple and has been used for several years	Low cost	Less acid consumption
4	Extraction unit	The system is locally manufactured	The system is easy to use and with simple training, anyone can learn	Efficiency energy conversion system	Glue extraction technology is a well-matured technology	low cost	High glue extraction rate from hide
5	Drying Unit	It is easily manufactured in a local workshop	Easy to use	A solar drying system is used	Solar drying is a matured technology	low cost	Effective drying with less energy usage

d) Energy and Mass Balance

A system for the daily capacity of 500 kg of glue has been designed from 2500kg of hide with the assumption of 20% waste conversion on the dry basis with a single extraction process (LLPIRDC). However, size reduction system is introduced. Besides, the second and third glue extraction can further improve the efficiency of conversion and the overall

extraction efficiency can reach up to 45 %. First, the mass and energy balance of the system is calculated and then the sizing of the system has been performed. The process considered for this mass and energy balance is shown in figure 11. The detailed calculation of the mass and energy balance is found Appendix section.

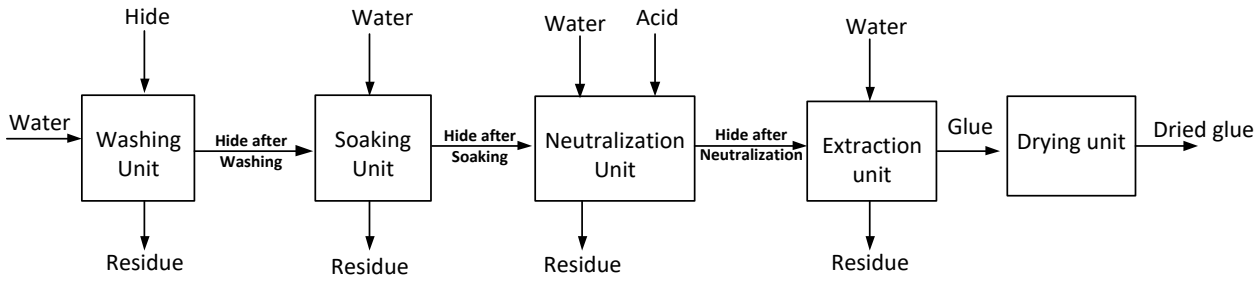

Figure 10 : Energy and Mass Balance

e) Application of glue

Glue can be used for various applications as follows with minor tweaking on the product specifications. Some of the envisaged applications for glue are outlined below.

Furniture: Furniture making relies heavily on glues and hide glue was the major adhesive for furniture manufacturing. Hide glues are excellent adhesives for many woods and for many uses. Hide glue was being used by the Egyptians as a furniture glue as far back as 2000 BC. This technique involves while using hide glue for furniture is coating half of the joint with hot hide glue, and then rubbing the other half against the joint until the hide glue starts to gel, at which point the glue becomes tacky. At this point, the plate is set aside without clamps, and the hide glue pulls the joint together as it hardens.

Glue (Additive used for painting bondage on walls) : In rural parts of Ethiopia, Glue is as an additive for painting bondage on walls. Glue that is less than 2 mm pellet size is used to paint adhesion on walls, to make the paint (water-based paints & quartz) more durable & more attached to the wall. It is widely known in the market for its deep brown color & stinky smell.

Construction: Hide glue can also be used during construction as a bonding to join materials by gluing. Adhesives can be used in construction in many situations:

ceramic tiles, lamination, Heating, ventilation, air conditioning connections, Timber jointing, Pre-fabricated panels, Resilient flooring Roofing and Wall coverings.

Book Binding: hide glue is used for to bind books and restoring old books as it is non-toxic and acid-free. However, epoxy glue is also very popular for restoring books. One of the very important priorities the hide glue must possess is that it has to be glue flexible enough so that it will not crack when the book is opened and closed multiple times.

Antique restoration: Hide glue is also used to repair Antique.

Besides hide glue can also be used during manufacturing, air conditioning industry, construction material assembly, prefabricated houses, Packaging etc.

f) Specific Property of Glue

The specific property of produced glue at the laboratory of LLPIRDC is shown in table 4.

Table 4 : Specific properties of glue produced at laboratory level by LLPIRDC, 2020

S. N	Specific properties	Value
1	Jelly strength	89 gm
2	Viscosity	14 CP
3	PH	2.8
4	Moisture content	17 %
5	Ash content	2%
6	Odor	Odorless
7	Color	Light brown

5.1.3. Institutions, Regulations, and investment climate Assessment

The tannery solid bi-products from tanneries management in Ethiopia involves multi-stakeholders from policymakers, regulatory bodies, development institute, sector initiatives, and private companies. Some of the organizations/actors and boundary partners involved in the solid bi-products from tanneries management or waste valorization interventions and their responsibilities and interlinkages are described as follows.

a) Environmental Protection Authority (EPA)

EPA is the lead government body responsible and legally mandated for environmental management and enforcement of environmental regulations. The Authority is responsible to ensure the realization of the environmental rights, goals, objectives, and basic principles enshrined in the FDRE Constitution as well as the Environment Policy. Environmental Protection Organs were established to monitor and enforce environmental laws/regulations. The Authority is mandated to protect and preserve ecosystems of the Ethiopian environment.

The below table describes some of the national applicable environmental regulations related to the manufacturing industry regarding environmental protection and pollution control.

Table 5 : National applicable environmental regulations related to the manufacturing industry concerning environmental protection and pollution control

S.N	Existing Environmental laws/regulations	Industry application
1	Environmental Pollution Control Proclamation No. 300/2002	No Industry shall pollute or cause any other person to pollute the environment Incentive: Tax exemption for importing new equipment that is destined to control pollution
2	Hazardous Waste Management and Disposal Control Proclamation No. 1090/2018	Any producer shall adopt the clean production principles to minimize hazardous wastes Industry needs to ensure the requirements for storing, labeling, transporting and disposing of hazardous wastes for both on-site and off-site operation
3	Prevention of Industrial Pollution, Council of Ministers Regulation No. 159/2008	The industry shall minimize the generation of pollutants and comply with environmental standards Every factory shall notify any potential pollutant, input or product under its possession
4	Solid Waste Management Proclamation-No. 51312007	Urban administrations shall create enabling conditions to promote investment in the provision of solid waste management services Request for a permit before engaging in the collection, transportation, use, or disposal of solid waste Ensuring that measures are taken to prevent pollution arising from the mishandling of solid bi-products from tanneries.

Ethiopia has been endorsing and implementing environmental laws and regulations. Even though the contents of these laws/regulations have few limitations that can be amended in the subsequent regulations/directives, there are visible gaps or challenges in implementing the laws.

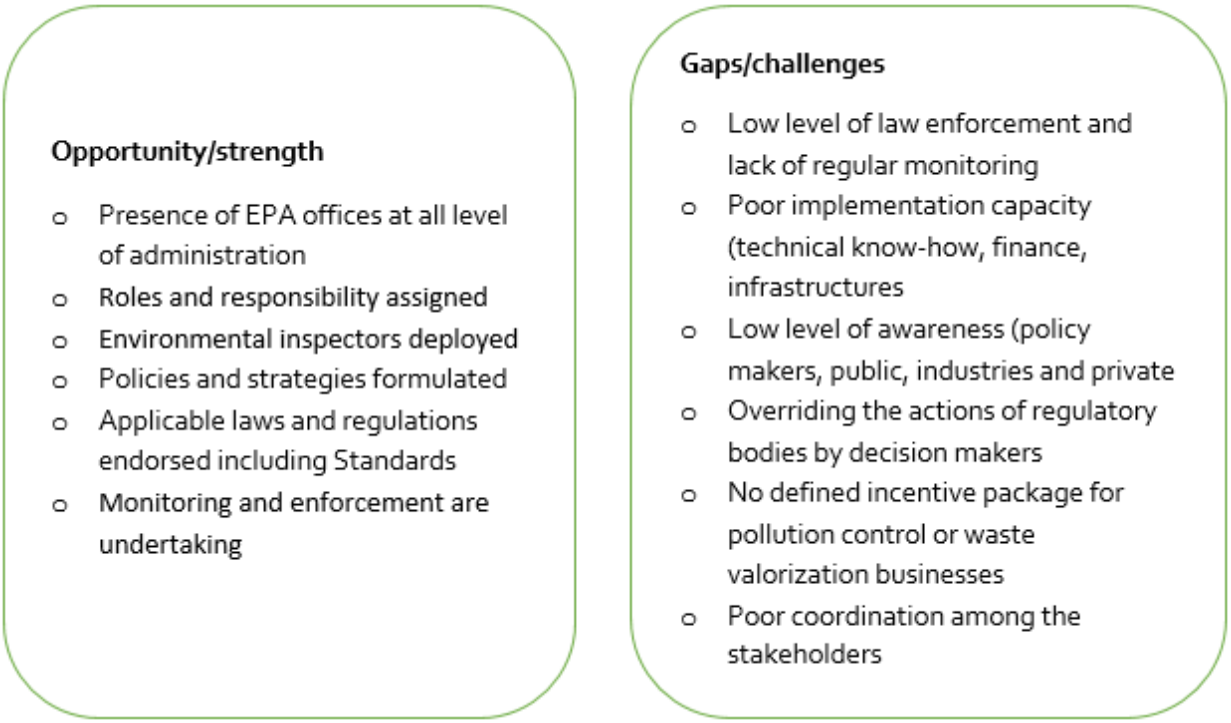

Figure 11: Opportunity/strength/gap/challenges of existing environmental policies

Furthermore, Ethiopia Standard Agency (ESA) in consultation with EPA is going to release additional supportive environmental regulations namely: Industrial Solid Waste Management Regulation and Guideline for Sludge Management. The regulation/guideline is supposed to improve the industrial waste management practices which can also drive waste valorization activities.

b) Ministry of Industry (MoI)/Leather and leather products industry Research and development center

The ministry's mission is to promote and expand the development of the industry by creating a conducive enabling environment for the development of investment and technological capacity of the industry sector by rendering efficient support and services to the development investor. To this end, the Ethiopia government formulated industrial policy and strategies to create conducive environments for industrial development

On the other hand, LLPI-RDC is established under the Ministry of Industry to provide necessary support and services to the leather industry in investment promotion and facilitation, production capacity building, marketing capacity building, policy initiation and implementation for tannery and leather garment industry that ensure customer and stakeholder need and expectation. As part of this work, LLPI-RDC is working in the areas of environmental protection and pollution control, resource efficiency and cleaner production and waste management to ensure environmental sustainability in leather sector.

Table 13: Some of the policy frameworks related with industrial development

S. N	Policies/strategies	Description/application to industry
1	Industrial development policy strategy (IDS), 2002	➢ Designed based on the following underlying principles of free- market economy: ✓ Accept that the private sector is the engine of the industrial development strategy ✓ Following the direction of Agriculture- led Industrialization ✓ Following Export-led Industrialization ✓ Focusing on Labor Intensive Industries ✓ Using Coordinated Foreign and Domestic Investment ✓ Mobilizing the whole society for industrial development ➢ The policy identified leather industry as one of the priority sectors
2	Ethiopian Industrial Development Strategic Plan (2013 - 2025)	➢ Provides the overall framework in terms of the vision, goal, strategies and programs that need to be implemented in the coming thirteen years in order to support the country's progress towards becoming a middle-income country by the year 2025 ➢ Its mission is "Building an industrial sector with the highest manufacturing capability in Africa which is diversified, globally competitive, environmentally-friendly, and capable

		of significantly improving the living standards of the Ethiopian people by the year 2025"
3	Ethiopia Leather Sector Value Chain strategy (2016-2020)	➢ **Vision**: To be a global leader in the manufacturing and trading of **environmentally friendly** and high-quality leather products. ➢ **Mission:** To facilitate the provision of technical, human and financial resources required to stimulate the growth and competitiveness of Ethiopian Leather Value Chain ➢ **Environmental objectives:** To promote environmental and sustainable production systems across the value chain ➢ To enhance resource optimization across the value chain

In addition, the Growth and Transformation Plan (GTP) – (2010/11-2014/15) aim for the industry sector to register a higher growth rate than that of the agriculture and service sectors. The target is to achieve an average annual growth rate of 20% as a base case scenario and 21.3% as a high case scenario. The targeted GDP share of the sector at the end of the plan period is 18.8% under the base case scenario.

The industrial policy/strategy of Ethiopia promotes environmentally friendly industries. MoI/ LLPI-RDC has been implementing these policies/strategies even if there were certain limitations. Hence, MoI/ LLPI-RDC will have the following supportive roles in realizing the proposed waste conversion businesses.

- Work with different stakeholders to improve the environmental performances of tanneries including waste valorization processes
- Provide technical support and capacity-building training
- Support in identifying budget sources for the projects
- Establish a binding modality between tannery companies and waste converting business

Regarding previous initiatives in waste conversion businesses, LLPI-RDC conducted 6 technical studies to convert tannery solid bi-products from tanneries to valuable products. The support is also continued in conducting the feasibility study.

c) Ethiopia Investment Commission (EIC)

The EIC is an autonomous government institution accountable to the country's investment board, which is chaired by the Prime Minister. The EIC's goal is to promote investment opportunities to foreign and domestic stakeholders. The EIC accommodates investors with centralized prominent institution services including the DBE, the CBE, the EIA, and the Ethiopian Customs & Revenues Authority.

d) Developmental Agencies

International partners or organization such as Solidaridad, GIZ, UNIDO, UNEP etc. has been collaborating/contributing to the development of the leather sector in Ethiopia to enhance the environmental sustainability of companies. Thus, the implementation of proposed waste valorization businesses will have a chance of being supported by these partners in terms of capacity building, technical support, finance, etc via their current and future sustainability programs/projects.

e) Ethiopian Leather Industries Association (ELIA)

Ethiopian Leather Industries Association (ELIA) is a nonprofit trade association of the leather industries businesses. ELIA works to enhance and improve the leather industry's business climate by promoting the export of leather, shoes, and leather goods and garment, protecting the rights of members, and assisting businesses to improve. ELIA, represents stakeholder interests for the industry which includes more than 100 members/factories. The association conducts seminars and workshops, provides technical support to industries, and organizes trade connections with importing countries and markets. Being environmental sustainability is the driving force for the international market, ELIA supports the tannery/leather companies to comply with environmental standards.

f) Support from Financial Institutions

In Ethiopia, credit facilities are granted by banks for projects based on the technical feasibility of the project, financial analysis, investment license, and demand for equity if it is a private limited company. As long as the project is feasible, securing funding from

banks might not be a challenge. The financial agencies check the financial background of the borrower to decide on the reliability and risk of the engagement. Of particular interest for financial institutes are securities in case the project fails. Such securities consist of state, components of the biogas plant, private company assets, and all other assets that cover the loan sum. Furthermore, the prospects of success of the project are analyzed. The success is usually estimated by checking several criteria that influence the economy of the future biogas plant (Zwedu, 2014).

The financial entities have been reviewed on how they are financing-related projects and renewable energies, especially the biogas sector. Development Bank of Ethiopia (DBE): Compared to other banks in Ethiopia, DBE is a top priority in considering project financing due to several factors. The DBE has two categories related to credit. Lease financing and project financing. Besides, the equity-to-debt ratio varies between 20/80 – 25/75 in DBE is an attractive beneficiary for the borrowers since other private and government banks request an equity-debt ratio of approximately range from 40/60 – 50/50 (Workalemahu, 2015).

Private and government banks: These bank sectors are potential sources of finance for manufacturing projects. However, compared to DBE, their interest rate is higher. Their major requirement is a 40-50% debt-equity ratio, feasibility study, and economic viability of the project.

The Modjo city administration's job creation directorate works closely with micro-financing institutions (such as Sinke Micro-finance) for facilitating access to finance for potential entrepreneurs. These micro-financing institutions provide loans with an interest rate of 13% and the condition for getting the loan is through providing collateral by the entrepreneurs and an amount of loan equivalent to the value of the collateral asset will be issued

International organizations: Ethiopia receives funds from several international organizations in a form of a loan or in-kind and cash towards promoting SMEs engaged in manufacturing in rural communities in Ethiopia.

g) Support from the Modjo City Administration and Community

Modjo administration town has been working with the government and different NGOs to solve the environmental impact of 13 tannery industries around the town. As part of this cooperation, Solidaridad and consortium partners People in Need (PIN), the lead partner, and International Rescue Committee (IRC) have launched a three-year European Union (EU) funded project. The Green Jobs in Leather Sector in Modjo, Leather Initiative for Sustainable Employment Creation (LISEC) project is being implemented in Modjo and the nearby communities in the Oromia Region, Ethiopia. The overall objective of the action is to create greater economic and decent employment opportunities, especially for young men and women through the development of the Ethiopian leather industry in Modjo.

The municipality welcomes the initiative because of two major reasons: the environmental and socio-economic impacts of the project and the job creation potential (as there are more than 6500 registered job seekers as per last year's assessment by the city administration on the 37 Kebeles under the city admin. More than 70% are below college graduation level).

Interview conducted with the Head of skill and job creation office showed that the town administration is fully committed to supporting any initiatives involving tannery solid bi-products from tanneries management including waste conversion businesses. The institutional support that can be provided to the businesses includes:

- Establish cooperatives/MSMEs that can engage in waste conversion businesses. Currently, there are more than 6500 unemployed individuals in the town
- Facilitate land acquisition to established MSMEs
- Provide technical support and capacity development training which can impact business and operations management skill levels
- Assist in market linkage through support letters to concerned bodies that can impact market access. It can also provide free access to trade fairs organized in the region.

- Facilitate logistic issues so that businesses easily transport the raw materials and waste generated from their businesses
- Influence the tannery industries to transfer the waste generated from their facilities free of charge or minimal cost up on close discussion or negotiation.

They also explained that tannery solid bi-products from tanneries management is one of the major challenges of the town that has been raising public complaints. Communities around Modjo town are aware of the environmental impacts of tannery industries even if they are not much aware of the solutions/intervention measures to alleviate the problem. Waste conversion businesses are not common in the area. But, some of the MSMEs are involving in the tannery solid bi-products from tanneries collection and glue production which is one of the wastes to valuable products conversion intervention measures/ businesses.

Even though the research was not conducted to analyze the degree of community acceptance/support for the proposed waste valorization intervention of the tannery solid bi-products from tanneries, communities around Modjo town will be expected to accept the proposed waste valorization intervention measures as long as the improper management of the wastes affects their life as witnessed from their complain. The significant rate of unemployment in the areas is also the driving force for the support of the projects.

Furthermore, the perception of the tannery factories is positive toward waste valorization businesses as evidenced by data collected from some of the tannery companies around Modjo town. They assume that intervention measures will reduce the environmental burden. The tanneries are willing to use some of the products that can be obtained from waste the recovery system as long as the products meet the quality parameters.

h) Private Company- Solid Waste Collectors

One of the actors along the waste management service value chain is the waste collectors. According to Solid Waste Management Proclamation-No. 51312007, any person shall obtain a permit from the concerned body of an urban administration before his/her engagement in the collection, transportation, use, or disposal of solid waste.

Given the support of the existing tannery waste collectors in Modjo town to the proposed waste conversation businesses, the Modjo town administration can integrate the existing collectors with the new businesses to facilitate the waste transportation activities with a reasonable service charge.

5.1.4. Market Assessment

a) PRODUCT DESCRIPTION AND APPLICATION

Glue (Additive used for painting bondage on walls)

Generally, Glue that is less than 2 mm pellet size is used to paint adhesion on walls, to make the paint (water-based paints & quartz) more durable & more attached to the wall. It is widely known in the market for its deep brown color & stinky smell. Mostly it is packed in a 25 kg plastic bag (Polypropylene sack).

Application

The Glue produced from tannery waste is mainly used for water-based paints. It will help add additional quality features to the ink due to its sticky property.

b) LOCAL MARKET

Past Supply Trend

The local demand for glue is met through both local production and import. Accordingly, the major findings of the trend in the past supply of glue are summarized below.

Local Production

In Ethiopia, a limited number of cottage & traditional producers are engaged in the glue manufacturing business. In this regard, there are no visible companies worth mentioning. It is believed, that during the period 2012-2022; local production of glue increased substantially, but it was difficult to investigate the registering average annual growth rate due to a shortage of data.

Import

Import of glue, which was 5,168 tons in 2012, has increased to 5,985 tons in 2021, registering an average annual growth rate of 3.1 %. During the same period, the value of

glue has increased from USD 9.5 million to Birr 12 million, registering an average annual growth rate of 1.7 %.

Table 6 : Imported Glue (Tons)

Year	Prepared Glues and other prepared Adhesives
2012	5,168
2013	6,943
2014	5,839
2015	7,724
2016	7,703
2017	8,268
2018	7,598
2019	8,183
2020	6,786
2021	5,985

Source: Ethiopian Revenues and Customs Authority

As it is indicated in the above table, the amount of glue imports is decreasing recently due to the hard currency shortage in the country. While surveying the market the imported glue is good in quality but it is not easily found in the market. The data gathered indicated that imported glue is not available in the market in recent times.

Total Supply or Apparent Consumption

Since there is no record of export and re-export of different types of glue observed during the period considered (2012-2021), the apparent consumption or total supply of different types of glue is composed of domestic production plus import. The market survey conducted indicated that currently imported glue market share is getting less and less and the share of local production is growing fast. Quality wise the imported good is much favored in the market since the odor is not disturbing & adhesive character is much strong.

The total supply amount of glue that includes the imported & local production is not officially known. The imported glue amount indicated above is including different types of

glues & local traditional glue manufacturers' production capacity was difficult to investigate.

Regarding market share, the maximum market share that local production captured is understood to be getting much higher in recent times, which indicates that the demand for glue for water-based paints is largely satisfied through local production.

Present Effective Local Demand

There are different approaches for estimating the demand for a product. Quantitative forecasting methods employed for this purpose are generally classified into two categories, time series, and causal. The pattern or behavior of the data in a time series has several components, such as horizontal, trend, seasonal, cyclical, and random (irregular) features. The trend component accounts for the gradual shifting of the time series to relatively higher or lower values over a long period. The data on flexible plastic packaging has a general increasing trend through time. One of the methods used to estimate the present effective demand is the time trend extrapolation method.

But the production capacity of the envisaged project is only **500 kg** per day; according to the market survey, there will be abundant market demand for this amount per day. Especially, the regional areas of the county's demand for this specific glue are high according to our market survey. Daily hundred quintals of glue are loaded from 'merkato' distributers & sent to different regional states of the country.

Factors that Influence the Market for Water-Based Paint Glue

In the process of demand estimation for glue, a thorough analysis of the set of factors that influence the demand for the products is very important. The first step in the process involves the analysis of the underlying characteristics of the target markets and their general macro-economic environmental aspects.

Accordingly, the variables that are essential in determining the magnitude and trend of demand for different water-based paint glue include:

- Performance of the national economy
- Rate of population growth and urbanization

- Government policy environment
- Import & foreign currency situation
- Performance of the construction sector.

Accordingly, a thorough assessment of the current status and prospect of these factors is conducted hereunder as they have a decisive influence on the likely direction of the demand for the products under consideration.

Factors That Affect Local Demand for Products Under Consideration

The demand for glue depends on the performance of the end users. Water-based paint users extensively use these materials. Moreover, other household users also use the products as a primary wall adhesive material, woodworking, and book binding.

Hence, past performance and the prospect of the manufacturing sector determines the magnitude of the demand for glue materials. Accordingly, a thorough assessment of the construction sector indicates that there is a progressively growing local demand for glue materials.

c) PRODUCT QUALITY

Product quality is one of the basic and most important marketing mixes that affect the success of a new product. Product quality has two dimensions, i.e., level and consistency.

Level means the producer must first choose a quality level that will be acceptable in the target market and at a level that complies with the quality of competing products. Consistency refers to the consistent delivery of one established quality through strict quality control measures. Accordingly, the envisaged factory should acquire capable machinery and a safe guarded production process with a system of optimally combined machine operations and control of them by qualified and trained technicians. Besides, quality control should be given top priority especially in selecting raw material, grade, and process control so that the envisaged factory could achieve its aims by producing the leading quality product.

d) PRICING

A proper quality control system considerably minimizes waste or the rejection of end products and thereby avoids complaints by customers. It also reduces the envisaged factory's operating costs as it facilitates timely corrective measures. Accordingly, the quality control service of the envisaged plant requires a laboratory appropriate for conducting tests of raw materials and final products. Based on the data collected from end users the recommended factory gate price is shown in table 6.

Table 7 : Factory Gate Price of Glue (Kg)

Sr. No.	Product Type	Price (Birr)
1	Glue	100

N.B. Price is mostly associated with raw material & transportation prices.

Table 8: Average Retail Price Considering Production Cost Elements

Description	Production volume/year	Variable cost per unit	Fixed cost per unit	Total Cost per unit	Assigned price	Gross Profit
Year 1	117,600.00	34.07	10.58	44.65	**100.00**	55.35
Year 2	126,000.00	31.80	9.88	41.68	**110.00**	68.32
Year 3	134,400.00	29.81	9.26	39.07	**121.00**	81.93
Year 4	142,800.00	28.06	8.72	36.77	**133.10**	96.33
Year 5 & after	151,200.00	26.50	8.23	34.73	**146.41**	111.68

For the envisaged project, its products are intermediate product used for water-based paint and the end user's geographical distribution is limited and are mostly located in or around major cities and towns of the country. Accordingly, by taking the nature of the products and the characteristics of the end users' direct distribution to end users is selected as the most appropriate distribution channel.

The envisaged factory is recommended to aggressively advertise its product by distributing calendars, and pamphlets as well as by participating in exhibitions and

bazaars. Moreover, in a competitive market, trade promotion should be made to persuade or to make a product attractive to end users. The envisaged factory is recommended to offer discounts on the volume of product bought and credit for four to six months.

e) DISTRIBUTION

Distribution refers to the distribution of the product to the consumers by the producer while the channel of distribution is the network of middlemen through whom the product flows till it finally reaches the hands of the actual users or consumers.

As the company's target market is the local market, the distribution will be in bulk to the potential whole seller and agent buyers with their requirements and its distribution channel are simple as long as the factory secures potential buyers.

f) PROMOTION

Market promotion is an important part of the marketing mix, as it is required to create and increase customer awareness, knowledge, and readiness to buy through media communications (advertising) and special offers to trade and /or consumers (sales promotion). However, it is important to realize that, on its own; market promotion will not replace selling, change long-term trends, or build long-term customer loyalty. It has to be supported by quality products and distribution efficiency.

As the target market of the envisaged Factory is the local market, the company should intensively advertise & promote its product locally using different outlets and networks (sector associations, municipality, trade fares, etc)

5.1.5. FINANCIAL STUDY

The financial evaluation takes into account the following assumptions

Table 9 : Financial evaluation assumption

Criteria	Assumption	Remarks
Production capacity (Kg/day)	500	
Working hrs/day	8	
Working days/month	26	
Working days/year	280	

Raw material (Hide trimming) cost including transportation cost (Birr/kg)	4 ETB	
Waste disposal cost (Birr/kg)	0.5ETB	
Packing size	25kg pp bag	
Market segment	Suppliers to building material outlets	
Product price (Birr/kg)	100ETB with an annual price increase of 10%	
Land price and building cost are measured in the cost of building in ETB per sq.m.	Corrugated sheet on wood frames for building and mortar-covered floor finish. For the compound, gravel compacting will be utilized	The land is assumed to be found free of charge.
Raw-material and final product transportation shall be outsourced	10% of the selling price of the commodity is committed to transportation cost	
Financial Sourcing	70% (Loan) with an interest rate of 11.5% and 30% (Equity from beneficiaries)	
Project lifetime (Years)	10	
Ideal capacity utilization	A progressively increasing capacity utilization is expected to start at 70% in year 1 and is expected to increase by 5% for the progressive years reaching a maximum capacity of 90% in year 5	

a) Infrastructure

Building and Civil Work

Based on the specification of the envisaged plant machinery and the project's internal requirements, the planned project will construct different buildings, a production hall, a service building, input, and output store tankers, guard posts, and loading and unloading area, water tanker tower, and green area.

The total area acquired for the project is 380 m^2.

Machinery and Equipment

The Investment in machinery and equipment is the major investment item, which determines the production capacity as well as the quality of the output.

Utilities

Water Supply

The water source of the project is the local municipal water supply. This source of water is not only important for fresh water used for drink, but it is also intended to be used for all sanitation activities of the project.

Electric Power Supply

The project requires about 24 kWh of power at full capacity for the production machinery.

b) Plant Capacity and Production Program

The selected machinery was designed for processing a net 500 kg of glue daily. In the preparation of the production program, it is advisable to consider different factors both from the internal and external factors of production, namely the contribution of the planned and unplanned maintenance downtime, technical knowledge, and time required for technical personnel to acquire adequate experience. Accordingly, considering the level of complexity of the technology, which is moderately medium, and the size of the market demand-supply gap, the capacity utilization is set at 60% in the first year of operation, 70% in the second year of operation. Following the acquirement of experience of technical, financial, and market factors of the environment, the envisaged plant will operate at maximum capacity utilization (90%) in the fourth year and then after. The detailed Plan of production capacity of the machinery is presented in the table below.

Raw Materials and Inputs

The required raw materials are: Processing Chemicals, Raw-Materials, Packaging Materials & Transportation

The following table outlines the processing chemicals, raw-material, other supplies such as packaging materials, and transportation costs considering the 500kg of net glue production capacity per day.

Table 10 : Raw Materials and Inputs

Sr.N	Description	Specification & Units of Measure	Amount/day	Unit Cost (Including transport)	Total Raw-material cost/month
1	Hide trimming (raw-material)	Kg/day	2500	2	130000
2	Chemicals	H2SO4(Liters/day)	37.5	120	117000
3	Waste disposal Cost	Kg/day	2000 *(Wet basis)*	0.5	26000
4	Packaging material	Pieces of 25kg sized PP bags	20	21	420

Manpower

Based on the planned capacity utilization and production design, the factory will employ 22 skilled, semi-skilled and unskilled individuals and will extend around Birr 916,800 annually for salaries and benefits in the initial year. The lists of employees needed for the project are listed in the following table.

Table 11 : Detail of Manpower requirement

Sr. No.	Position	No. Required	Salary/month	payment per month	Annual Salary
1	General manger	1	8,500	8,500	102,000
2	Executive secretary	1	2,500	2,500	30,000
3	Finance responsible	1	4,000	4,000	48,000
4	Supervisor	1	4,000	4,000	48,000
5	Operators	11	3,400	37,400	448,800
6	Quality control in charge	1	3,000	3,000	36,000
7	Production area cleaner	2	1,600	3,200	38,400
8	Security guard	1	2,400	2,400	28,800
9	Marketing & procurement officer	1	4,000	4,000	48,000
10	Warehouse in charge	1	4,000	4,000	48,000
11	Driver	1	3,400	3,400	40,800
Aggregate		**22**	**40,800**	76,400	**916,800**

c) Financial Assessment Results

Total Investment Costs & Source of Finance

The sources of finance for the loan will be long-term loans obtained from local Microfinance enterprises. The total planned investment cost in the initial year is around Birr 3,374,452 of which the financing of the project consists of bank loans and promoter's equity. Consequently, out of the total investment cost, 70% will be a bank loan and 30% will be an equity contribution. The detail of the financing scheme and source of finance is summarized in the table below: -

Table 12 : Detail Fund Allocation

Sr. No.	Investment Items	Owner Equity (Birr)	Bank Loan (Birr)	Total Cost (Birr)
1	**Fixed Investment**			
	Main Machinery	126,093	294,216	420,309
	Auxiliary Equipment	28,001	65,335	93,335
	Office equipment & furniture	35,550	82,950	118,500
	Vehicle	303,600	708,400	1,012,000
	Building Development	307,950	718,550	1,026,500
Sub-Total		**801,193**	**1,869,450**	**2,670,644**
2	**Working Capital**	**191,293**	**446,350**	**637,642**
3	**Pre-Production Costs**			
	Pre-production Cost	19,850	46,316	66,166
	Pre-production Interest	-		-
Sub-Total		**19,850**	**46,316**	**66,166**
Grand Total		**1,012,335**	**2,362,116**	**3,374,452**
Percentage		**30%**	**70%**	**100%**

The above table assumes the investment financing approach. However, depending on the types of business owners (such as: factory owners, private investors or cooperative MSMEs), the ownwers' equity proportion presented on the table above can also be assumed to utilize investment financing options such as lease financing and seed funding.

Working capital is the amount of money permanently needed in cash or in kind to keep the business operating while it is awaiting full payment for goods sold to customers. The total working capital considered for the project reaches up to 637,642 ETB annually. The

major cost centers considered in allocating working capital include Local raw materials, Packing materials, Utility Costs, Wages & salaries, Marketing & Promotional Cost, Product Transportation Cost, Work in Progress, Finished Product, Training Cost and other miscellaneous costs have been considered. The total duration of the working capital varies from a cost center to cost center and the detailed working capital allocation is presented in the annex section below.

Revenue & Profitability Projection

The total revenue expected from this project is assumed to derive from the production of glue. During the first year of production, the project will start at 70% of its theoretical production capacity, then every year the project will increase its production performance by 5% until it reaches 90% in the 5th year. Therefore, the projected income is assumed to increase based on the project production performance. The projection for the income statement is primarily derived from market-based sales estimates, which are adequate market assessments and guaranteed sales from previous experiences. The average annual projection of the revenue obtained from the sales of glue is estimated to be Birr 11,760,000 in the first year and expected to grow to Birr 15,120,000 at the end of the 5th year onward. The annual net profit to be generated by the company will grow from Birr ***5,920,023*** in its first year to Birr **7,207,088** in the 10th year. The detailed cash flow projections are presented in the appendix section below.

Balance Sheet

The Net Capital of the company will grow from about ***Birr* 3,374,452 *in*** year one to ***Birr* 44,481,886 *by*** the end of year ten. A detail of the projected balance sheet is attached in the annex part of the business plan. The detailed balance sheet is presented in the annex section below.

Net Present Value & Internal Rate of Return (IRR)

Present Value is one of the discounted cash flow techniques which fully recognizes the time value of money. An investment is viable if the NPV has a positive value and this project has a projected NPV of **Birr 25,623,430** considering an annual discount rate of 10%. The Internal rate of return (IRR) is the rate at which the discounted net returns are equal to the original investment in the project. If the IRR of a particular project is higher

than the minimum required rate of return, also known as the cost of capital, the said project can be accepted. Based on the computations for this project, the IRR of the project is found to be more than 150%.

Sensitivity Analysis

As shown below, the project is not sensitive to possible variations in revenue decrease, operating cost & investment increase. This shows that changes in the cost centers under each of the categories may vary with no/ little impact on the business viability.

Table 13: Sensitivity Analysis

		FIRR Before Tax
Revenue Decreased by 10%		121%
Operating cost Increased by 10%		124 %
Investment cost Increased by 10%		134%

5.1.6. Environment, Occupational Health, and Safety Risk and Impact Assessment

The glue production from hide-limed trimmings involves major processes such as washing, soaking, neutralization, extraction, filtration, drying, and packaging. These processes make use of different resources such as water, chemicals (acids) and energy. In this project, a solar panel is used to the energy required for extraction, pumps, and drying(optional). Wood can be used to heat the glue during extraction. Regarding waste generation, liquid wastes from washing/soaking & neutralization and solid bi-products from tanneries (residue) from filtration or extraction is generated from glue production.

Based on the technical study conducted by LLPIRDC, the proposed glue production generates more than 14m^3 wastewater per day from the aforementioned sub-processes assuming that 85% of the water used goes to wastewater. On the other hand, the process generates 500kg/day of solid residue(dry) assuming that the moisture content of hide

limed trimmings is 60% and the waste conversion efficiency is 20% on dry basis. Table 13 illustrates the environmental aspects/impacts with corresponding mitigation measures.

Table 14: Environmental aspects/impacts with corresponding mitigation measures

S. N	Environmental aspects	Environmental Impacts	Mitigations measures
1	Use of hide-limed trimmings as raw materials	End up with residue that can cause land pollution	• Proper storage of the residues and off-site disposal • Residues can be used for the production of compost (if this business exists)
2	Use of chemicals-acids	Wastewater emissions to land or water bodies	Two intervention measures can be considered*

*****The wastewater generated from glue production is expected to be slightly basic and slightly polluted. There are also no wastewater discharge limits for such type of process in Ethiopia. Moreover, it is not economical for the MSMEs to construct Effluent Treatment Plant (ETP). Hence, the following intervention measures can be considered:

1. Establish the waste conversion businesses nearby the common Effluent ETP to be constructed for the Modjo leather city so that businesses will get an opportunity to drain their wastewater to the common facility.
2. Drain the wastewater into the environment after conducting pre-treatment processes which include screening and gravity sedimentation.

Note that:

Modjo town administration and other concerned bodies need to support these MSMEs regarding the environmental issues.

Similarly, there are some hazards related to occupational health and safety of workers along the value chain of production. Table 14 below illustrates risks and the corresponding mitigation plan.

Table 15: Risks and corresponding mitigation plan

S. N	Type of hazards	Exposure routes	Risks	Mitigation plan
1	Chemical-physical and health	Inhalation, skin	Health, burning	Use of Acid resistant PPE, automatic dosage
2	Formation of odor, hot objects Physical hazardous	Inhalation Skin	Health risk Burning of skin	Use of appropriate PPEs

Good housekeeping and proper maintenance can also improve the environmental performance of the processes and enhance workers' safety. Moreover, precautions should be taken to avoid the corrosion of the structures while working with acids.

Furthermore, the positive environmental impacts of the proposed project may include:

- ✓ Reduce solid bi-products from tanneries that otherwise pollute the environment when disposed to land
- ✓ Improve the compliance/conformance of the tannery factories with national or international standards/codes of conduct

5.1.7. Socio-economic Impact Assessment

Production of glue from hide-limed trimming has a vital socio-economic impact (positive impact) in terms of resource consumption patterns, job creation/income generation, environmental protection & societal health, cost reduction, compliance, etc. In general, tanning industries, unemployed individuals particularly youth, society around Modjo town, and the government will be benefited from such type of business. Table 15 illustrates the anticipated socio-economic benefits to be obtained from the glue production project around Modjo town.

Table 16 : Socio-economic Impact Assessment production of glue from hide-limed trimmings

Indicators/Criteria	Socio-economic benefits
Socio-economic benefit/cost indicators	○ Create job opportunities for 22-25 and 314-357 persons at 7% and 100% of bi-product utilization respectively. ○ Additional job creation opportunities for indirect actors in the value chain ○ Tanning industries gain benefit from the proper waste disposal, and may earn additional money from selling the waste ○ Foreign currency saved from reduced import of the products (glue) ○ Generates income tax for the government
Environmental and health benefit /cost indicators	• Reduce the quantity of solid bi-products from tanneries to be disposed of (Approx.140,000kg/year on dry basis or 350,000Kg/year on wet basis) • Improved public health (reduced level of exposure to pathogens and toxic substances)

Furthermore, the above-mentioned waste conversing business has the socio- economic impacts/benefits

- Improve land use of the town in terms of minimizing areas occupied by waste disposal sites
- Become part of solutions toward addressing public complaints in the surrounding. Change the perception/attitude of the surrounding communities
- The projects are useful for knowledge and technology transfer for similar waste conversion businesses both existing and new establishments. For instance, traditional glue producers around Modjo town can benchmark their production practices against the proposed glue production project
- Contribute to developing the skill-base of the future and potential of enhancing stakeholder relation
- In general, enhance solid bi-products from tanneries management practices of the tanneries (both national and international requirements) as well as the sanitation and hygiene of the area.

5.2. Project 2: Preparation, characterization, and application of protein hydrolysate from chrome-bearing solid bi-products from tanneries

5.2.1. Waste supply and Availability

a) Sources, quantity, and quality of generated waste

Chrome-bearing waste is one of the highly generated solid bi-products from tanneries. Major chrome-containing solid bi-products in the tannery are shavings, trimmings & splits. Considering the existing practices of managing these solid bi-products from tanneries in Ethiopia, tanneries normally collect shavings (with some of the trimmings) & splits (unusable) and separately store them in their premise until disposal together with other dried solid bi-products from tanneries. In some cases, there may be a mixing of dried solid bi-products from tanneries during storage on the tannery's premises. The disposal is in an open land at the site identified by the governing town where the tanneries are situated. The chrome shaving waste is the second huge amount of tannery solid bi-products from tanneries next to fleshing bi-product. Chrome shaving accounts for 30-35% of solid bi-products generated in leather manufacturing industries (Kanagaraj et al. 2006). Chrome-containing wastes are considered hazardous waste. Chrome tanned shavings hardly discompose and they lead to disposal (Bethelhem 2018).

Table 17: Generation ratio of Chrome-containing solid bi-products from tanneries w.r.t input material weight

Waste type	Average Mass (kg) of waste per kg of input material			
	Hide		Skin	
	Wet basis	Dry basis	Wet basis	Dry basis
Wet blue trimmings	0.044	0.038	0.019	0.016
Wet blue shavings	0.104	0.083	0.056	0.045
Wet blue splits	0.154	0.128	0	0

Source: LLPIRDC- Own computation (averaging) based on data collected from different tanneries over time

Considering about thirteen tanneries around Modjo town, the total quantity of chrome containing solid bi-products from tanneries over the last ten years (2004-2013 E.C.) has been estimated. The actual soaking performance during the indicated period is taken into account and the estimated amount of chrome-bearing solid bi-products from tanneries is presented in table 17.

Table 18: Estimated amount of Chrome containing solid bi-products from tanneries for tanneries around Modjo town (2004-2013 E.C.)

Waste type	**Estimated average Mass (in tons)**			
	Hide		Skin	
	Wet basis	Dry basis	Wet basis	Dry basis
Wet blue trimmings	6,937.4	3,607.5	1,757.8	914.1
Wet blue shavings	16,187.4	7,769.9	5,273.4	2,531.2
Wet blue splits	24,062.3	0.128	0	0

Source: LLIPRDC-Own computation to estimate total solid bi-products from tanneries based on actual soaking performance.

To relatively have a country-wise picture of chrome containing solid bi-products from tanneries generation, it has been estimated by own computation using trend analysis based on the last five years (2008-2012 E.C.) soaking performance of all tanneries. The chrome-bearing wastes (chrome shaving, chrome trimmings, and chrome tanned splits) generated at the beginning of the projected period were estimated to be 7.1 million kg/year and 2.5 million kg/year on wet and dry mass respectively.

In addition, the maximum chrome-bearing solid bi-products from tanneries generated at the end of the projected period it was estimated that 9.4 million kg/year and 3.3 million kg/year on wet and dry mass respectively. Moreover, the daily chrome-bearing wastes were estimated from 25.56 thousand kg/day to 33.9 thousand kg/day and 8.9 thousand kg/day to 11.8 thousand kg/day based on wet and dry mass, respectively.

Therefore, from the estimated chrome-bearing wastes generation table, the above analysis indicated that the country has a huge potential chrome-bearing wastes availability for protein filler and chrome recovery plants.

Table 19 : Computed chrome-bearing waste generation of the tanneries for the projected year

Description	Project period (in EC)									
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Estimated Chrome-bearing wastes										
The estimated amount of chrome shaving kg/ year	3,307,728	3,898,105	3,629,070	3,863,913	4,034,560	4,172,517	4,205,927	4,419,892	4,524,360	4,639,544
The estimated amount of chrome trimmings kg/ year	1,044,546	1,230,981	1,146,022	1,220,183	1,274,072	1,317,637	1,328,187	1,395,756	1,428,745	1,465,119
The estimated amount of chrome tanned splits kg/ year	2,804,592	3,300,836	2,969,531	3,123,150	3,191,944	3,257,115	3,209,007	3,334,024	3,354,692	3,390,078
Total Chrome bearing waste generation based on wet mass kg/year	7,156,866	8,429,922	7,744,624	8,207,245	8,500,575	8,747,269	8,743,121	9,149,672	9,307,797	9,494,741
Total Chrome bearing waste generation based on dry mass kg/year	2,504,903	2,950,473	2,710,618	2,872,536	2,975,201	3,061,544	3,060,092	3,202,385	3,257,729	3,323,159
Total Chrome bearing waste generation based on wet mass kg/day	25,560	30,107	27,659	29,312	30,359	31,240	31,225	32,677	33,242	33,910
Total Chrome bearing waste generation based on dry mass kg/day	8,946	10,537	9,681	10,259	10,626	10,934	10,929	11,437	11,635	11,868

Wet blue trimmings and shavings are usually collected and stored together and wet blue split, which is normally stored alone unlike the former two. Depending on the status of these wastes (storage duration and conditions), the moisture content may vary accordingly. One of the main challenges associated with chrome-containing solid bi-products from tanneries is their poor biodegradability when disposed to the environment. Thus, apart from probable differences in moisture contents of such solid bi-products from tanneries over time, there may not be stability issues affecting the quality (LLPIRDC).

b) Reliability of resource supply

The majority of hide/skin (≥ 80%) is tanned with basic chromium sulfate across the globe so far (Buljan and Kral 2015). Therefore, there won't be a supply limitation of wet blue shavings, trimmings, and split. Shaving and trimming are among common operations in leather processes in addition to splitting. Hence, chrome-containing solid bi-products from tanneries are available every month as long as tanning and post-tanning operations are undertaken.

However, nature of rawhide/skin (substance (husbandry mode, species), technology in use (machinery, chemical, human skill, etc.), type of final intended product requirements (thickness range, firmness), etc. are factors having a direct impact on the level to which the above three operations to be handled. This in turn induces variations in the amount of these chrome-bearing wastes to be generated. Wet blue splits, shavings, and trimmings are normally stored and eventually disposed of in an open landfill. Thus, such solid bi-products from tanneries are not yet consumed for any other industrial purposes, which in turn signifies their unlimited availability.

Regarding transport, these solid bi-products from tanneries are usually disposed to open landfill via vehicle transportation. The same means can handle the supply of it to waste converting plant. If a plant converting chrome-containing solid bi-products from tanneries into useful products is located nearby the tannery cluster, the supply of these wastes will be easy and possibly at a minimal cost.

c) Competitors' index for waste resource

Conversion of chrome-containing solid bi-products from tanneries to other useful products has been tried but these are high-value products and/or require strict and separate processing. Glue, gelatin, protein flavor, reconstituted collagen and leather board, etc. are among products that can be made from these solid bi-products from tanneries. However, obtaining protein hydrolysate for use as a filler in leather making is the easier one to handle. In Ethiopia, no other industrial processes are demanding chrome-containing solid bi-products from tanneries as input. Hence, there is no competition with the supply of such wastes so far.

Inferring the existing practice, tanneries don't lose any if they supply chrome-containing wastes for free. Binding modality could be made between the two entities (tannery & waste converting plant) such that solid bi-products from tanneries could be supplied with no or minimal cost (1-2 ETB/kg) with the understanding that the tannery would get back protein hydrolysate and recovered chrome at a fair price for use. In general, the supply (quantity), reliability, quality, and price of the chrome-bearing wastes will not significantly affect the proposed business as long as the waste is properly segregated at tanneries, obtained with no or minimal cost, binding modality b/n tanneries and waste converting businesses established in terms of waste supply & cost of products and expected increase in waste volume.

5.2.2. Technical and Logistical Assessment

After the chrome tanning process and during the finishing process, the leathers are prepped to the required specification with splitting and shaving methods. During this operation, large quantities of chrome-containing solid bi-products from tanneries are generated in the tanneries as shown in Figures 13 and 14. Concerning the solid balance in the conversion of hides and skins into leather, out of every 1,000 kg of salted hides, only 260 kg are finally converted into leather. Among the remaining solids, 230 kg are in

the wet blue state, comprising 100 kg shavings, 110 kg unusable splits, and 20 kg trimmings.

Figure 12 : Chrome Split

Figure 13 : Chrome Shaving

a) Process Description

The process of producing Protein hydrolysate preparation processes starts from collecting and preparing the chrome shaving and splits for the process as shown in figure 1. The collected chrome-bearing solid waste (chrome shaving and splits) is then pretreated with water and surfactant. The pretreated chrome-bearing waste was then processed using the Alkaline Hydrolysis process. Alkaline hydrolysis uses water, alkaline chemicals, and heat to accelerate natural decomposition, leaving bone fragments and a neutral liquid called effluent. After Alkaline hydrolysis, the filtration process follows. The filtration process is done using a filter or screw press. After the filtration process, two products will come out: hydrolysate and chrome cake.

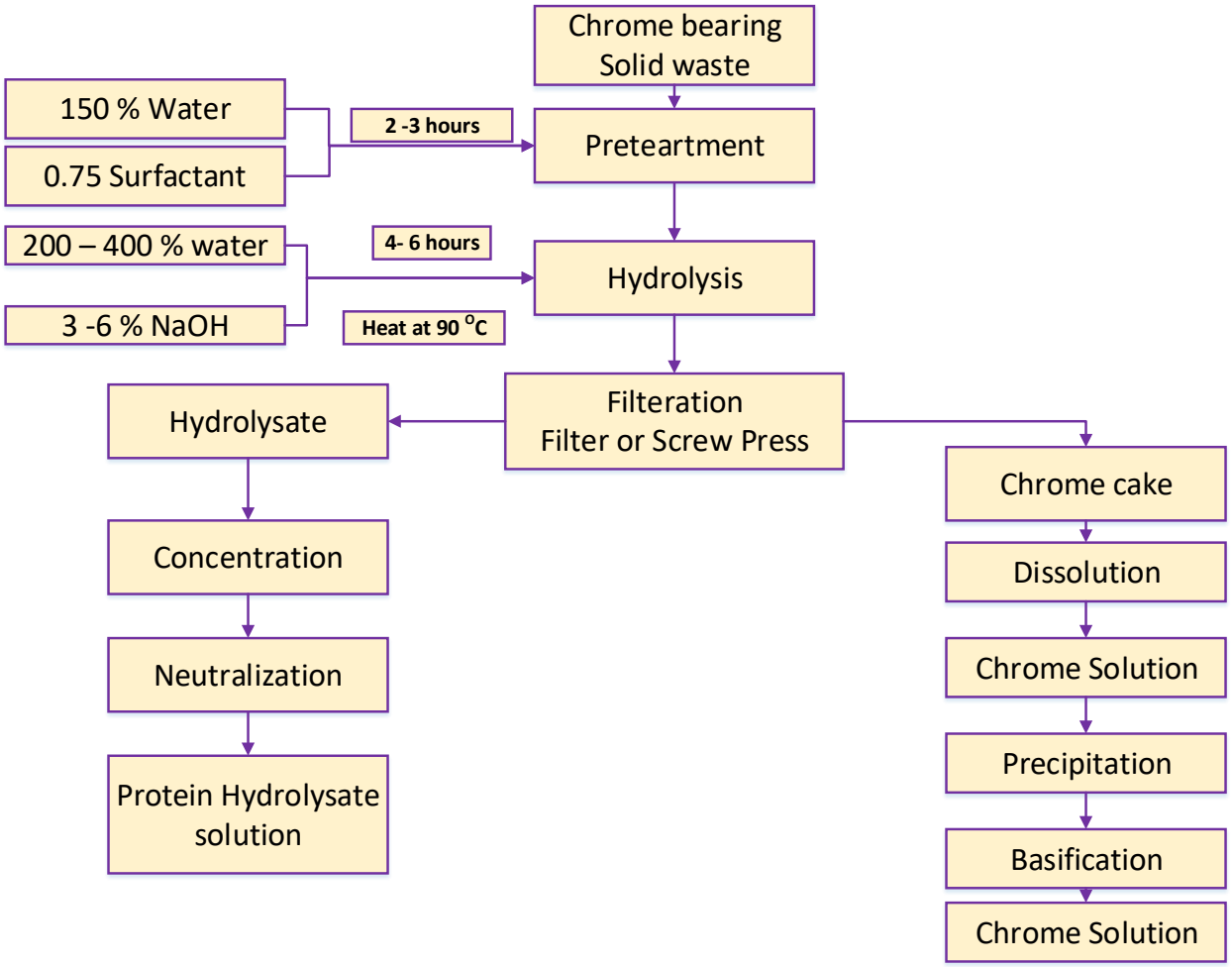

Figure 14 : Process map of Protein hydrolysate and Chrome from Chrome Bearing Solid bi-products from tanneries

On one hand, the produced hydrolysate is concentrated and neutralized to produce the required concentrated protein hydrolysate solution. On the other hand, the Chrome cake is dissoluted to get a chrome solution. The chrome solution is then precipitated followed by a basification process to get the required chrome solution with the right concentration.

b) Description of the Process Steps

Collection of chrome solid waste: chrome shaving and splits are collected from the nearby tanneries. Getting the right amount of solid waste at the right time and requirement is very important. It is also important to locate the processing unit within the proximity of those tanneries to reduce the logistics cost of transportation. Solid waste segregation is

a very important step for this process to get only the chrome shaving and chrome splits as they are mixed with other waste as well. Waste segregation is the sorting and separation of waste by its types.

Pretreatment: The collected chrome shaving and split is suspended in water such that 5 kg water was added for each kg of shavings, and 0.5 % non-ionic surfactant (Pluronic® 25R2) will be added to prevent foaming. Chrome Shaving and splits, water, and surfactant are tumbled or mixed at 16 rpm for 2-3 h in a tanker or reservoir prepared for this purpose with a temperature of around $70^{O}C$ (Cabeza et al. 1998).

Alkaline Hydrolysis: High amount of collagen, which is a natural protein present in the hide or skin. Alkaline hydrolysis is used to extract this protein. Alkaline hydrolysis is performed with 2-4 % sodium hydroxide (NaOH) concentration, at 90 °C, 3 hours reaction time with an agitator rotating at around 6 rpm, and a solid/liquid ratio of 1/70 g/mL (Beltrán-Prieto and Kolomaznik 2012).To get to obtain a hydrolysate with high protein content and low chromium content the parameters of Alkaline hydrolysis i.e. reaction time, temperature, stirring rate, and alkali must be controlled. It is worth mentioning that pH was monitored during the entire process, and adjusted to 9.0 as needed to maintain optimum alkalinity for avoiding chrome dissolution and promoting enzyme activity (HINOJOSA and SALDAÃ‘A 2020).

Filtration Process: The reaction mixture from the alkaline hydrolysis process is filtered through filter press or screw press as shown in Figure 16 to obtain hydrolysate and chrome cake. This process is required to separate collagen hydrolysate from the chrome cake.

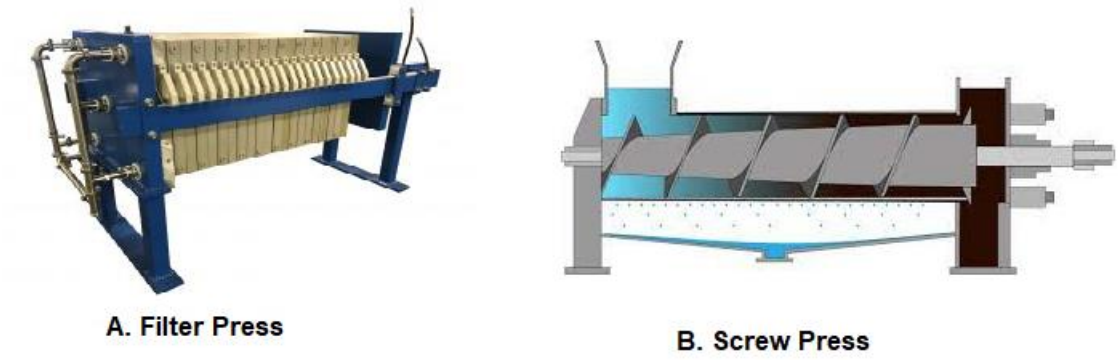

Figure 15: Filtration Machine

c) Hydrolysate Recovery System

The produced Hydrolysate is concentrated and neutralized with further treatment to get concentrated protein Hydrolysate.

d) Transforming protein Hydrolysate solution to solid

A solar drying system is used to remove the water content from the produced protein Hydrolysate solution. The final product is in solid form.

Figure 16: Solar drying system to transform Transforming protein Hydrolysate solution to solid form

During the drying process of the protein hydrolysate solution, the system is well insulated and no moisture will enter the system from the surrounding atmosphere after drying the

solid part is immediately inserted into a manual grinding machine to change solid protein Hydrolysate into powder form. Thus, if the solution is dried using a well-insulated system and converted into powder immediately after drying, preservation of the protein hydrolysate does not require.

e) Manual Grinding Machine (to change solid protein Hydrolysate to powder form)

The different small-scale motorized grinding machine has been checked as shown in figure 18. The team also visited the Addis Ababa Institute of technology's laboratory to see a small-scale motorized grinding machine for producing powder from solid materials.

Figure 17: Small-scale motorized grinding machine to change solid material to powder form (Chemical Engineering Laboratory, Addis Ababa Institute of technology)

Thus, to save energy cost and to use the system continuously without electric power, a manual grinder machine to change solid protein Hydrolysate to powder form is recommended as shown in figure 19 for our purpose.

Figure 18: Small-scale manual grinding machine to change solid protein Hydrolysate to powder form

a) Chrome recovery system

According to (HINOJOSA and SALDAÃ‘A 2020), the chrome cake was dissolved in concentrated sulfuric acid (23% on weight of initial chrome shavings) to give a pH of 1.0±1.2. The process was started in two large buckets of drum. Next, the pH was slowly raised to 1.9±2.1 by the addition of small aliquots of a 50% (w/w) solution of sodium hydroxide. The mixture was heated for 30 min at 60 ^{o}C and allowed to stand overnight at room temperature. Organic materials were then removed from the chromium solution by filtration. The filtrates then were adjusted to pH 9 with 50% (w/w) sodium hydroxide to precipitate the chromium. The solution containing suspended chromium was then heated, not to the boiling point as per the recommended temperature (Okamoto and Katano 1974) by Okamoto [18], but to more than 70 ^{o}C. The solution, therefore, was kept at this temperature for 2 h and was allowed to settle for 2 to 3 h. Chromic oxide was recovered from this mixture-using filter press and washed with water. The process of recovery of chrome is shown in figure 20.

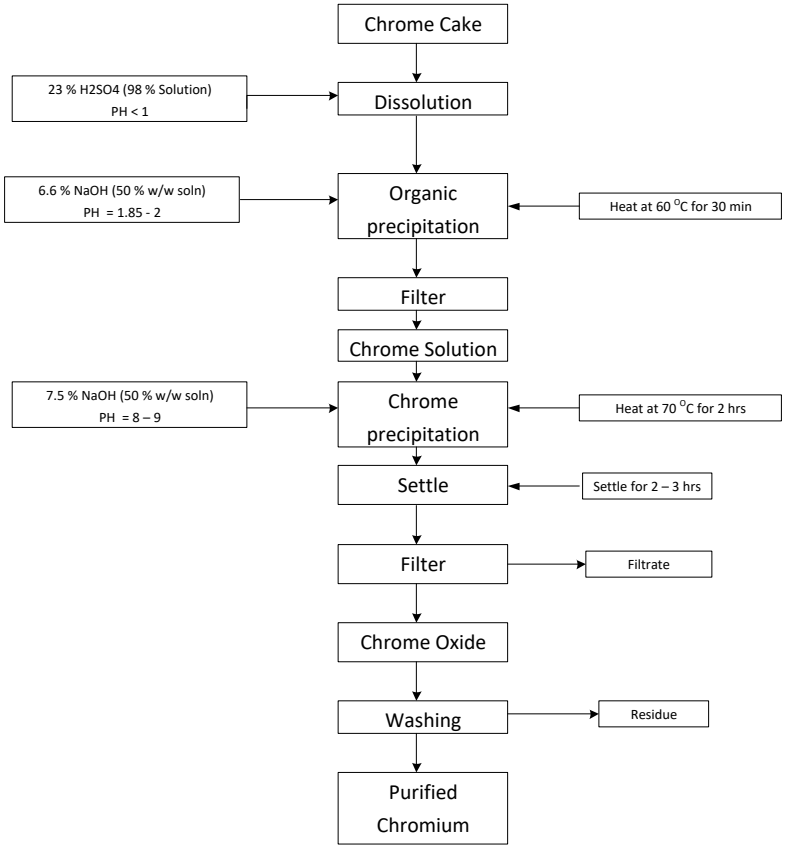

Figure 19 : Flow diagram of the procedure for purification of chrome cake (HINOJOSA and SALDAÃ‘A 2020)

b) Technology selection of filtration process

Table 20 : Decision Matrix Filtration system - Selection of Technology

Filtration system		
Criteria (Rating 1-10)	**Filter press**	**Screw Press**
Cost of components	9	5
Ease of reproducibility of the component locally	6	9
Energy use	5	10
Ease of use	7	7
Labor requirement	8	9
Capacity	9	8
Time taken for the overall process	9	7
Suitability	10	7
Totals	63	62

The manual Filter press is selected based on the matrix and suitability for our purpose.

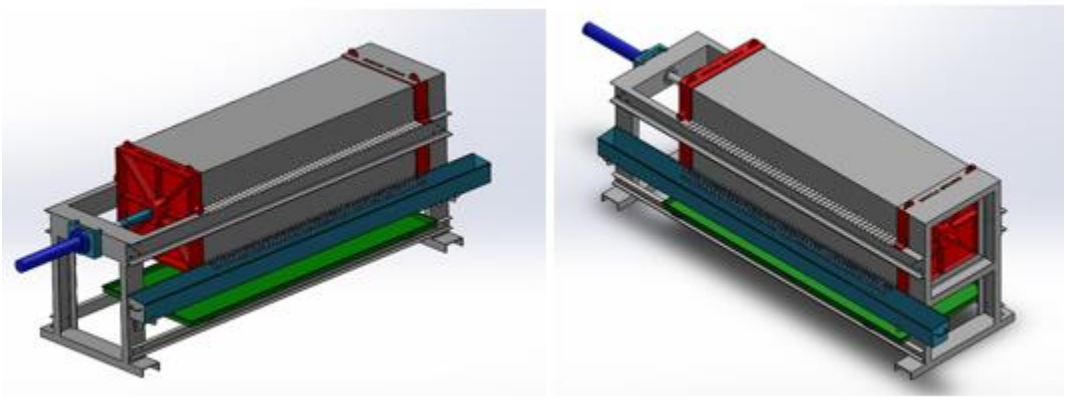

Figure 20 : Manual Filter Press with the possibility of local manufacturing

Even though a screw press is easy to manufacture locally and easily, due to the suitability and the liquid nature of the solution, a manual filter press is recommended. The number of solid parts within the solution is the determining factor in selecting the right filter pressing technology. A dewatering screw press usually separates liquids from solids. It has to be noted that a screw press can be used in place of a filter press. To be used for Alkilin hydrolysis solution, it has to be designed to squeeze the material against a screen with a membrane filter included, and then the liquid is collected after passing the membrane screen for collection and use. Screw press with membrane screen is shown in Figures 19 and 20.

Figure 21: Motorized screw Press

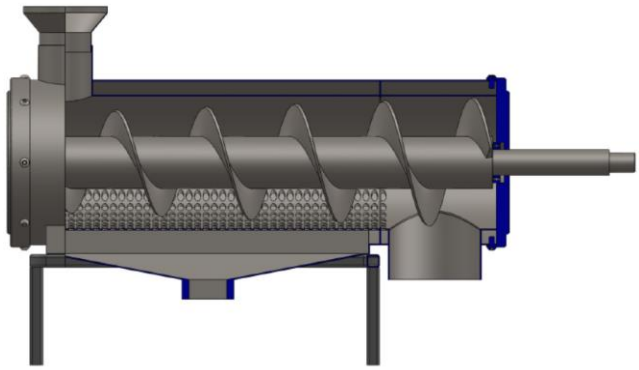

Figure 22: Sectional view of Manual Screw press selected for our case

Controlling the required parameters of the production process continuously and frequent laboratory tests for the produced product will assure the product quality.

c) Specific properties of protein hydrolysate and recovered chrome

The specific properties of protein hydrolysate and recovered chrome produced by is shown in table 21 and 22.

Table 21 : Specific properties of protein hydrolysate and recovered chrome produced by LLPIRDC, 2020

Properties	Description
Product	: Protein hydrolysate
Product application	: As a filler for leather processing
Source	: Chrome bearing solid wastes
Color	: Liquid: Light to dark brown
	: Solid powder: light Beige
pH	: Liquid: 5.5-6.5
	: Solid: 5.6-6.5 (@ 1:10 water)
Total solid content (g/L)	: Liquid: 125 ± 1.5
Organic nitrogen content (% N_2)	: Liquid: 14.5 ± 0.25
Ash content (%)	: Liquid:11.5-12.5 (Sulphated)
	: Solid: 24 ± 0.5 (Total ash)
Active Matter (Total organic substance)	: Liquid: 88 ± 0.5 g/L
	: Solid: 76 ± 0.5%

Table 22 : General profile of recovered chrome (liquid state)

Properties	Description
Product	: Basic Chromium Sulphate
Product application	: As a tanning for leather processing
Source	: Chrome bearing solid wastes
Color	: Greenish liquid
pH	: 2.8-3.0
Basicity (%)	: 34 ± 0.5
Preparation method	: Alkaline hydrolysis
Total solid content (g/L)	:3.4 ± 0.1
Organic nitrogen content (% N_2)	: ~ 0.2
Ash content (% Sulphated)	: 2 ± 0.2
Chromic oxide content (g/L)	: 3.6-3.8
Hexavalent Chromium (ppm)	: < **0.1**

The protein filler produced has been applied at Awash and Ethiopia tanneries, in which satisfactory results were obtained with respect to quality of products.

Internationally, besides its applications for the leather industry, protein hydrolysates have an important role in the food industry applications as emulsifying, foaming and gelling ingredients. Protein hydrolysates can also be applied to food products to extend the shelf life. Moreover, the additional bi-product of the process, recovered chrome, can also be reused for tanning the pelt.

5.2.3. Market Assessment

a) MARKET STUDY

PRODUCT DESCRIPTION AND APPLICATION

Protein Hydrolysate and Basic-chromium-sulfate (BCS)

Basic-chromium-sulfate (BCS) is a chrome chemical mostly required as the main tanning agent in the chrome tanning process in the leather industry.

Protein Filler

Protein filler provided considerable softness and light and highly voluminous feel without causing problems to the leather.

Application

As a tanning agent, Basic chromium sulfate shows excellent penetration capabilities and guarantees a high-quality wet blue. It also provides uniform chromium oxide distribution on the cross-section and the grain of the leather.

b) LOCAL MARKET

Past Supply Trend

The local demand for Basic chromium sulfate is met through import. Accordingly, the major findings of the trend in the past supply of protein filler & basic chromium sulfate is described below.

Import

Import data for Basic chromium sulfate separately was not available. Sulfates; Alums; Peroxosulfates & Persulfates general import, which was 5,582 tons in 2012, has increased to 12,547 tons in 2021. This shows that the import of sulfate chemicals is increasing.

Table 23: Imported Sulfates; Alums; Peroxosulfates & Persulfates (Tons)

Year	Sulfates; Alums; Peroxosulfates & Persulfates
2012	5,582
2013	7,387
2014	9,275
2015	8,244
2016	8,583
2017	7,815
2018	3,513

2019	8,979
2020	11,358
2021	12,547

Source: Ethiopian Revenues and Customs Authority

Total Supply or Apparent Consumption

Since there is no record of export and re-export of sulfates observed during the period considered (2012-2021), the apparent consumption or total supply of sulfate is composed of only imports.

Regarding market share, the maximum market share that imports captured is understood to be getting much higher in recent times, which indicates that the demand for tannery chemicals is only satisfied through import.

Present Effective Local Demand

There are different approaches for estimating the demand for a product. Quantitative forecasting methods employed for this purpose are generally classified into two categories, time series, and causal. The pattern or behavior of the data in a time series has several components, such as horizontal, trend, seasonal, cyclical, and random (irregular) features. The trend component accounts for the gradual shifting of the time series to relatively higher or lower values over a long period. The data on flexible plastic packaging has a general increasing trend through time. One of the methods used to estimate the present effective demand is the time trend extrapolation method.

But the production capacity of the envisaged project is only **1000 kg** per day; according to the market survey, there will be abundant market demand for this amount per day. Especially, the tannery industries of the country's demand for these specific tannery chemicals is high according to our market survey. Daily hundred quintals of chemicals are being consumed by tannery industries.

Factors that Influence the Market for Tannery Chemicals

In the process of demand estimation for Tannery chemicals, a thorough analysis of the

set of factors that influence the demand for the products is very important. The first step in the process involves the analysis of the underlying characteristics of the target markets and their general macro-economic environmental aspects.

Accordingly, the variables that are essential in determining the magnitude and trend of demand for different tannery chemicals include:

- Performance of the national economy
- Rate of population growth and urbanization
- Government policy on the environment
- Import & foreign currency situation
- Performance of the tannery industry sector.

Accordingly, a thorough assessment of the current status and prospect of these factors is conducted hereunder as they have a decisive influence on the likely direction of the demand for the products under consideration.

Factors That Affect Local Demand for Products Under Consideration

The demand for tannery chemicals depends on the performance of the tannery industries. Tannery industries extensively use these materials.

Hence, past performance and the prospect of the manufacturing sector determine the magnitude of the demand for protein filler & basic chromium sulfate. Accordingly, a thorough assessment of the tannery industries indicates that there is a progressively growing local demand for these chemicals.

c) PRODUCT QUALITY

Product quality is one of the basic and most important marketing mixes that affect the success of a new product. Product quality has two dimensions, i.e., level and consistency.

Level means the producer must first choose a quality level that will be acceptable in the target market and in a level that complies with the quality of competing products. Consistency refers to the consistent delivery of one established quality through strict quality control measures.

Accordingly, the envisaged factory should acquire capable machinery and safeguard the production process with a system of optimally combined machine operations and control of them by qualified and trained technicians. Besides, quality control should be given top priority especially in selecting of raw material, grade, and process control so that the envisaged factory could achieve its aims by producing the leading quality product.

d) PRICING

A proper quality control system considerably minimizes waste or the rejection of end products and thereby avoids complaints by customers. It also reduces the envisaged factory's operating costs as it facilitates timely corrective measures. Accordingly, the quality control service of the envisaged plant requires a laboratory appropriate for conducting tests of raw materials and final products. Based on the data collected from end users the recommended factory gate price is shown below.

Table 24 : Factory Gate Price of Protein Filler & Basic Chromium Sulfate (Kg)

Sr. No.	Product Type	Price (Birr)
1	Protein Filler	150
2	Basic Chromium Sulfate	-

Table 25 : Average Retail Price Considering Production Cost Elements

Description	Production volume/year	Variable cost per unit	Fixed cost per unit	Total Cost per unit	Assigned price
Year 1	207,106.67	29.24	11.16	40.40	**150.00**
Year 2	221,900.00	27.29	10.42	37.71	**165.00**
Year 3	236,693.33	25.58	9.77	35.35	**181.50**
Year 4	251,486.67	24.08	9.19	33.27	**199.65**
Year 5 & after	266,280.00	22.74	8.68	31.42	**219.62**

For the envisaged project, its products are intermediate product used for tannery industries and the end users' geographical distributions is limited and are mostly located in or around Modjo. Accordingly, by taking the nature of the products and the characteristics of the end-user's direct distribution to end users is selected as the most appropriate distribution channel.

The envisaged factory is recommended to aggressively advertise its product to the tannery industries. Moreover, in a competitive market, trade promotion should be made to persuade or to make a product attractive to end users. The envisaged factory is recommended to offer discounts on the volume of product bought and credit for four to six months.

5.2.4. FINANCIAL STUDY

The financial evaluation takes into account the following assumptions

Table 26: Financial evaluation assumptions

Criteria	Assumption	Remarks
Production capacity (Kg/day)	1000 (protein filler) & 57Kg (Chrome)	
Working hrs/day	8	
Working days/month	26	
Working days/year	280	
Raw material (Birr/kg)	1.0 ETB	
Waste disposal cost (Birr/kg)	----	
Packing size	25kg pp bag with inside lining plastic	
Market segment	Suppliers to leather processing factories	
Product price (Birr/kg)	150 ETB with annual price increase of 10%	
Land price and building cost measured in the cost of building in ETB per sq.m.	Corrugated sheet on wood frames for building and mortar-covered floor finish.	Land is assumed to be found free of charge.

	For the compound, gravel compacting will be utilized	
Raw-material and final product transportation shall be outsourced	10% of the selling price is estimated for transporting the final product to customers.	
Financial Sourcing	70% (Loan) with an interest rate of 11.5% and 30% (Equity from beneficiaries)	
Project life time (Years)	10	
Ideal capacity utilization	A progressively increasing capacity utilization is expected to start at 70% in year 1 and is expected to increase by 5% for the progressive years reaching a maximum capacity of 90% in year 5	

a) Infrastructure

Building and Civil Work

Based on the specification of the envisaged plant machinery and the project's internal requirements, the planned project will construct different buildings, a production hall, a service building, input and output store tankers, guard posts, and loading and unloading area, water tanker tower and green area.

The total area acquired for the project is 330 m^2 with an estimated overall construction cost of 851,500 ETB. The overall cost estimation for the construction can be accessed in the annex section below.

Machinery and Equipment

The Investment in machinery and equipment is the major investment item, which determines the production capacity as well as the quality of the output. Utilities

Water Supply

The water source of the project is the local municipal water supply. This source of water is not only important for freshwater used for drink, but it is also intended to be used for all sanitation activities of the project.

Electric Power Supply

The project requires about 160KWh of power daily at full capacity for the production machinery.

b) Plant Capacity and Production Program

The selected machinery was designed for processing a net 1000 kg of protein hydrolysate and chrome daily. In the preparation of the production program, it is advisable to consider different factors both from the internal and external factors of production, namely the contribution of the planned and unplanned maintenance downtime, technical knowledge, and time required for technical personnel to acquire adequate experience. Accordingly, considering the level of complexity of the technology, which is moderately medium, and the size of the market demand-supply gap, the capacity utilization is set at 60% in the first year of operation, 70% in the second year of operation. Following the acquirement of experience in technical, financial, and market factors of the environment, the envisaged plant will operate at maximum capacity utilization (90%) in the fourth year and then after. The detailed Plan of production capacity of the machinery is presented in the table below.

Raw Materials and Inputs

Processing Chemicals, Raw Materials, Packaging Materials & Transportation

The following table outlines the processing chemicals, raw-material, other supplies such as packaging materials and transportation costs considering the 1000 Kg of net protein hydrolysate production capacity per day.

Table 27 : Processing Chemicals, Raw Materials, Packaging Materials & Transportation

Sr.N	Description	Specification & Units of Measure	Amount/day	Unit Cost (Including transport)	Total Raw-material cost/month
1	Chrome shaving & split	Kg/day	1753	1	45585.2
2	Chemicals	H2SO4, HCL(Liters/day) NaOH	Different proportions	2500	64987.4
3	Waste disposal Cost	Kg/day	701.3	0	0
4	Packaging material	25kg size	42	21	887.6

Manpower

Based on the planned capacity utilization and production design, the factory will employ **18** skilled, semi-skilled and unskilled individuals and will extend around Birr 753,600 annually for salaries and benefits in the initial year. The list of employees needed for the project is listed in the following table.

Table 28 : Detail of Manpower requirement

Sr. No.	Position	No. Required	Salary/month	payment per month	Annual Salary
1	General manger	1	8,500	8,500	102,000
2	Executive secretary	1	2,500	2,500	30,000
3	Finance responsible	1	4,000	4,000	48,000
4	Supervisor	1	4,000	4,000	48,000
5	Operators	7	3,400	23,800	285,600
6	Quality control in charge	1	3,000	3,000	36,000
7	Production area cleaner	2	1,600	3,200	38,400
8	Security guard	1	2,400	2,400	28,800
9	Marketing & procurement officer	1	4,000	4,000	48,000
10	Warehouse in charge	1	4,000	4,000	48,000
11	Driver	1	3,400	3,400	40,800
Aggregate		**18**	**40,800**	62,800	**753,600**

c) Financial Assessment Results

Total Investment Costs & Source of Finance

The sources of finance for the loan will be long-term loans obtained from local Microfinance enterprises. The total planned investment cost in the initial year is around Birr 4,311,598 of which the financing of the project consists of bank loans and promoter's equity. Consequently, out of the total investment cost, 70% will be a bank loan and 30% will be an equity contribution. The detail of the financing scheme and source of finance is summarized in the table below: -

Table 29 : Detail Fund Allocation of investment cost

Sr. No.	Investment Items	Owner Equity (Birr)	Bank Loan (Birr)	Total Cost (Birr)
1	**Fixed Investment**			
	Main Machineries	339,543	792,268	1,131,811
	Auxiliary Equipment	22,500	52,500	75,000
	Office equipment & furniture	42,750	99,750	142,500
	Vehicle	303,600	708,400	1,012,000
	Building Development	255,450	596,050	851,500
Sub-Total		**963,843**	**2,248,968**	**3,212,811**
2	**Working Capital**	**304,274**	**709,972**	**1,014,246**
3	**Pre-Production Costs**			
	Pre-production Cost	25,362	59,179	84,541
	Pre-production Interest	-		-
Sub-Total		**25,362**	**59,179**	**84,541**
Grand Total		**1,293,479**	**3,018,119**	**4,311,598**

The above table assumes the investment financing approach. However, depending on the types of business owners (such as: factory owners, private investors or cooperative MSMEs), the ownwers' equity proportion presented on the table above can also be assumed to utilize investment financing options such as lease financing and seed funding.

Working Capital Requirements

Working capital is the amount of money permanently needed in cash or in kind to keep the business operating while it is awaiting full payment for goods sold to customers. The total working capital considered for the project reaches up to 1,014,246 ETB annually (for the 1st year). It is expected to increase yearly based on the capacity utilization increase. The major cost centers considered in allocating working capital include Local raw materials, Packing materials, Utility Costs, Wages & salaries, Marketing & Promotional Cost, Product Transportation Cost, Work in Progress, Finished Product, Training Cost and other miscellaneous costs have been considered. The total duration of the working capital varies from a cost center to cost center and the detailed working capital allocation is presented in the annex section below.

Revenue and Profitability Projection

The total revenue expected from this project is assumed to derive from the production of glue. During the first year of production, the project will start 70 % of its theoretical production capacity, then every year the project will increase its production performance by 5% until it reaches 90% in the 5th year. Therefore, the projected income is assumed to increase based on the project production performance. The projection for the income statement is primarily derived from market-based sales estimates, which are adequate market assessment and guaranteed sales from previous experiences. The average annual projection of the revenue obtained from the sales of protein hydrolysate and chrome is estimated to be Birr 29,400,000 in the first year and is expected to grow annually as per the yearly increase in capacity utilization. The annual net profit to be generated by the business will grow from Birr ***21,338,576*** in its first year increasing year on year. The detailed cash flow projections are presented in the annex section below.

Balance Sheet

The Net Capital of the company will grow from about ***Birr* 4,273,625 in** year one to ***Birr* 150,165,405** by the end of year ten. A detail of the projected balance sheet is attached in the annex part of the business plan. The detailed balance sheet is presented in the annex section below.

Net Present Value & Internal Rate of Return (IRR)

Present Value is one of the discounted cash flow techniques which fully recognizes the time value of money. An investment is viable if the NPV has a positive value and this project has a projected NPV of **Birr 81,902,364.12** considering an annual discount rate of 10%. The Internal rate of return (IRR) is the rate at which the discounted net returns are equal to the original investment in the project. If the IRR of a particular project is higher than the minimum required rate of return, also known as the cost of capital, the said project can be accepted. Based on the computations for this project, the IRR of the project is found to be way more than 200%.

Sensitivity Analysis

As shown below, the project is not sensitive to possible variations in revenue decrease, operating cost & investment increase. This shows that changes in the const centers under each of the categories may vary with no/ little impact on the business viability.

Table 30: Sensitivity Analysis

		FIRR Before Tax
Revenue Decreased by 10%		>100%
Operating cost Increased by 10%		>100%
Investment cost Increased by 10%		>100%

Finally, the idea is financially feasible and bankable, economically successful, socially and environmentally acceptable, and worthwhile to pursue.

5.2.5. Health and Environmental Risk and Impact Assessment

Handling chrome-bearing solid waste requires special care. Solid residues from chrome tanning are shavings, buffing dust, and unusable (mostly wet blue) split, as well as the crust and finished leather trimmings. Due to strict environmental regulations, disposal of chrome-containing solid bi-products from tanneries in some countries may pose a significant disposal problem (Buljan and Kral 2015). Chromium used in leather tanning is a source of significant contamination, especially the oxidation of chromium Cr3+ to the

form of Cr6+, which is a threat to humans because of its mutagenic and carcinogenic potential. Leaks from chrome-tanned solid waste and high chromium concentrations in wastewater can lead to soil and groundwater contamination (Famielec 2020).

One of the waste valorization techniques applied to chrome-bearing solid waste is the preparation of protein hydrolysate and chrome recovery. Protein hydrolysate preparation processes involve pre-treatment, alkaline hydrolysis, filtration/filter press, concentration, neutralization, and drying(optional). After hydrolysis, the filter press separates protein hydrolysate from chrome cake. Further treatments such as dissolution, precipitation, and basification are applied one after the other to recover the chrome from the residue. 20-35% of the fresh chrome input can be substituted by recovered chrome (Green World Consult 2012).

Protein hydrolysate production and chrome recovery processes utilize chemicals (surfactants, acids/bases), water, and energy. Following this process, wastewater is generated at pre-treatment and chrome precipitation processes. Similarly, sludge/residue is generated from organic precipitation and the subsequent washing process. It should be noteworthy to mention that such effluent could let be mixed with general effluent in ETP, and could be easy if a tannery can operate the conversion of this solid waste.

Based on the technical study conducted by LLPIRDC, the proposed protein hydrolysate and chrome recovery generate more than $18m^3$ wastewater per day from the aforementioned sub-processes. The chrome and protein content of both supernatant and filtrate has been analyzed and found to be negligible. On the other hand, the process generates 12.75kg/day (sludge amount generated is 0.0075 kg per kg of input waste (on dry mass basis).

Table 19 below illustrates the environment, occupational health, and safety risk assessment of the stated waste conversion intervention measure.

Table 31: Environment, occupational health and safety risk assessment of the stated waste conversion intervention measure

S. N	Process	Hazard	Associated risk/impact	Mitigation plan
1	Pre-treatment, chrome precipitation	Wastewater emission	No significant environmental impact	Two intervention measures can be considered*
2	Hydrolysis/neutralization	Use of base/acid	Physical and health hazards	Use of appropriate PPE
3	Chrome precipitation	Use of acids	Physical and health hazards	Use of appropriate PPE
4	Chrome recovery unit	Sludge generation	Land or water pollution	Store properly and dispose of as hazardous waste
5	Across the value chain	Chemical drums	Land pollution, health risk	Properly washing and transferring to licensed waste collectors

*The wastewater generated from this waste conversion is expected to be slightly basic and slightly polluted. There are also no wastewater discharge limits for such type of process in Ethiopia. Moreover, it is not economical for the MSMEs to construct Effluent Treatment Plant(ETP). Hence, the following intervention measures can be considered:

1. Establish the waste conversion businesses nearby the common Effluent ETP to be constructed for the Modjo leather city so that businesses will get an opportunity to drain their wastewater to the common facility.
2. Drain the wastewater into the environment after conducting pre-treatment processes which include screening, neutralization, and gravity sedimentation.

Note that:

Modjo town administration and other concerned bodies need to support these MSMEs regarding the environmental issues.

Furthermore, the positive environmental impacts of the proposed project may include:

- ✓ Reduce the disposal of chrome-bearing solid bi-products from tanneries which is one of the hazardous wastes generated by the leather industry
- ✓ Enhance circularity of production in the tannery industry in Ethiopia

- ✓ Improve the compliance/conformance of the tannery factories with national or international standards/codes of conduct

5.2.6. Socio-economic Impact Assessment

Utilization of Protein hydrolysate and Recovered chrome from chrome-bearing solid bi-products from tanneries has an important socio-economic impact (positive impact) in terms of resource consumption patterns, job creation/income generation, and environmental protection & societal health, cost reduction, compliance, etc. In general, tannery industries, unemployed individuals particularly youth, society around Modjo town, and the government will be benefited from such type of business. Table 20 illustrates the anticipated socio-economic benefits to be obtained from this project.

Table 32 : Socio-economic Impact Assessment of Utilization of Protein hydrolysate and Recovered chrome from chrome-bearing solid bi-products from tanneries

Indicators/Criteria	Socio-economic benefits
Socio-economic benefit/cost indicators	○ Create job opportunities for 18-20 and 108-120 persons at 16.6% and 100% of bi-product utilization respectively. ○ Additional opportunity for job creation to indirect actors in the value chain ○ Foreign currency saved from reduced importation of substituted input materials (chrome and protein filler) ○ Create an opportunity for tanneries to recycle resources which reduces raw material and logistic costs ○ Generates income tax for the government.
Environmental and health benefit /cost indicators	• Partly solve the challenges related with the disposal of chrome-bearing wastes • Reduce the quantity of solid waste to be disposal (Approx.368,130kg of chrome shaving waste) • Improved public health (reduced level of exposure to pathogens and toxic substances) • Reduce/avoid disposal cost of the chrome-bearing waste • May contribute to regulatory change/amendment for better law enforcement

Furthermore, the above-mentioned waste conversing business has the following socio-economic impacts/benefits

- Improve land use of the town in terms of minimizing areas of occupied by waste disposal sites
- Become part of solutions toward addressing public complain in the surrounding. Change the perception/attitude of the surrounding communities
- Contribute to developing the skill-base of the future and potential of enhancing stakeholder relation
- In general, enhance solid waste management practices of the tanneries (both national and international requirements) as well as the sanitation and hygiene of the area.

5.3. Project 3: Utilization of de-dust salt from raw hide/skin in pickling process

5.3.1. Waste supply and Availability

a) Sources, quantity, and quality of generated waste

Common salt is used for hide/skin preservation. Before soaking, the salt is mechanically or manually removed from hides and skins which leads to de-dusted salt waste. This waste is contaminated with blood, hair, bacteria, dirty and etc (USAID 2018).

Different studies showed that de-dusted salt can be purified and re-utilized for pickling process without compromising the quality of the leather products.

The below table illustrates the rate of generation of de-dusted salt at the study area (Modjo town) based on the following basic data/assumptions.

S. N	Description	Response	Remark/Reference
1	Currently operating number of tannery factories around Modjo	12	
2	Number of working days/years	280	
3	Average actual production or soaking capacity (pieces/year)		
	Hide	1,039,717	

	Skin	10,407,595	
4	**De-dusted salt/waste**		
	Kg of waste/pc of hide	0.4	Results from technical study*
	Kg of waste/pc of skin	0.032	
	Quantity of de-dusted waste (Kg/year)	748,930	
	Quantity of de-dusted waste (Kg/day)	2,675	
	Quantity of de-dusted waste (Kg/day) assuming that 85% is salted hide/skin	2,274	

Other study conducted in Ethiopia showed that the average salt generated by desalting 1 piece of hide using dome type Dodeca wooden frame is 0.517Kg. Similarly, an average of 0.1034 Kg of de-dusted salt is generated from 1 piece of skin (Checkole 2018). In this case, the quantity of de-dusted waste generated will increase. Thus 1,613,679 kg/year or 5,763kg/day of de-dusted salt can be generated. Accordingly, the average rate of generation de-du-dusted salt is 3,586 kg/day for the 12 tannery industries based on the two studies at 85% salted hide/skin inputs.

Currently, SOLIDARIDAD is in the process of supplying a locally manufactured de-salting machine to tanneries around Modjo area. This would have positive impact on the project. On the other hand, this initiative will also enable the investment cost for the de-salting machine will be deducted from the overall investment cost of the recycling of the de-dusted salt project.

b) Reliability of resource supply

The quantity and quality of de-dusted salt are not significantly differed from season to season. The de-dusted salt is available every month as long as the company is using salted hides/skin. Limitation of the waste occurs while the company is processing unsalted hide/skin

The range of quantity of de-dusted salt waste might increase or decrease based on the input quantity of salted rawhide and skin as well as the production plan. De-dusted salt is stable enough over time during storage and can be easily collected and transported.

Most of the tannery industries in Ethiopia perform the de-dusting of salt manually by shaking hides and skins with hands. Apart from this, no tannery factory in Ethiopia recycles de-dusted salt except Ethiopia tannery which recycles very small portions of the waste (LLPIRDC)

c) Competitors' index for waste resource

In Ethiopia, most tannery companies dispose of the de-dusted wastes at the dumping sites together with other solid bi-products from tanneries. Hence, there is a possibility to get the waste free of cost. However, few companies re-use the de-dusted salt for the preservation of raw hides and skins even if this application is not recommended due to bacterial impact. But yet not scientifically proved.

In general, the supply (quantity), reliability, quality, and price of the de-dusted waste will not significantly affect the proposed business as long as the waste is properly de-dusted and collected at tanneries, obtained with no or minimal cost, and binding modality between tanneries and waste converting businesses established in terms of waste supply & cost of products and expected increase in waste volume.

5.3.2. Technical and logistical assessment

Raw hides and skin are preserved before being processed into leather and a large quantity of salt is sprinkled onto the animal hide. The salt absorbs moisture, which inhibits the growth of bacteria, from the hide. Cattle hide, for instance, needs between 10 kg and 12 kg of salt per hide. Furthermore, salt prevents deterioration, which means the hide will remain in a good condition. If necessary, this process is repeated several times. With well-known efficiencies and low cost of curing these sodium salts are applied widely in tanneries in Ethiopia. Hides without a preservative can allow the growth of microorganisms instantaneously, which can reach a level of several million per milliliters and damage the hides in only 5 - 6 h (Vankar and Dwivedi 2009).

Figure 23 : A pile of salted skin at Ethiopian Tannery, Modjo

Even though curing hide with salt is a good preservation method, the curing salts generate a huge amount of pollution and salinity in the form of total dissolved solids and chlorides during leather processing.

Figure 24 : Desalting of salted hide at Ethiopian Tannery, Modjo

a) Process description

The process starts by removing the salt sticking to the hide and skin surface by shaking the hides mechanically, manually using dry dedusting, mechanical brushes, or using a sieve drum type shaker to eliminate up to 15-18% of the salt added to hides and skins for preservation as shown in figure 30. The de-dusted salt is mixed with water. Some of the

dirt particles are filtered. Thus, this process gives us a salt solution. However, the process needs further treatment using Aluminum sulfate. Aluminum sulfate is a salt with the formula $Al_2(SO_4)_3$. It is soluble in water and is mainly used as a coagulating agent (promoting particle collision by neutralizing charge) in the purification of drinking water. The dusted salt is prepared as a 12 % solution. The solution is screened to remove hair, tissue, sand, and other insoluble matters. More than 90% of the suspended solids, about 60 % of COD, and 80 % of BOD are removed by settling. Natural salt applied for the preservation of skins can be recovered by de-dusting. However, salt must be recovered before soaking the skin to control the chloride contents in the final effluent. Controlling the required parameters of the production process continuously and frequent laboratory tests for the produced product will assure the product quality.

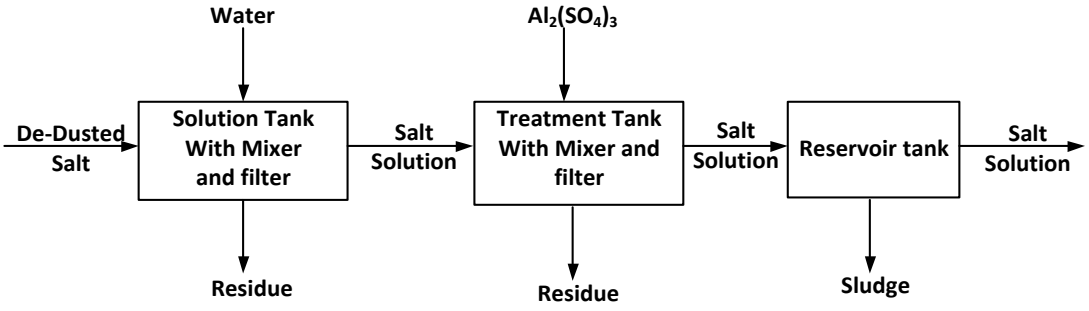

Figure 25 : Salt recovery process/system from de-dusted salt

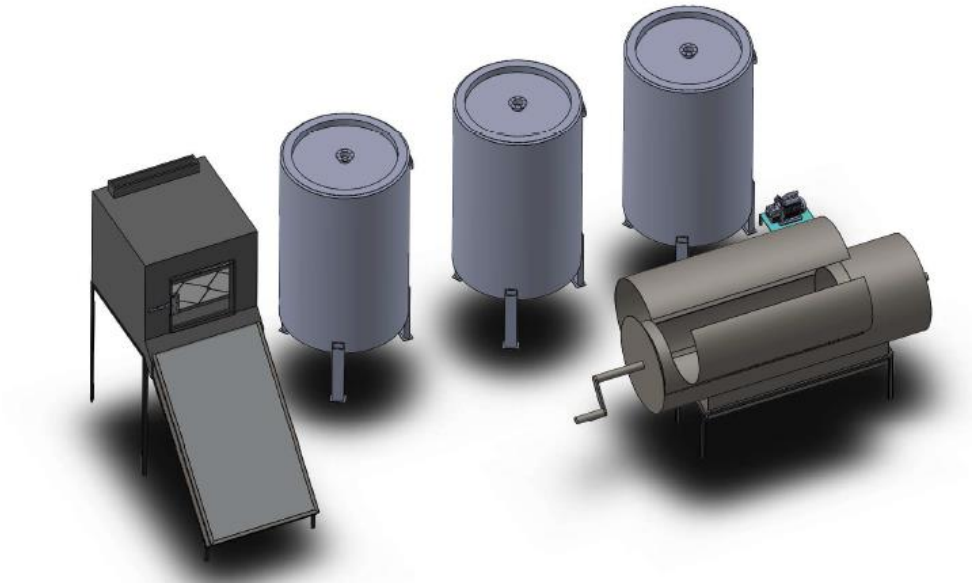

Figure 26 : Overall salt recovery system with solar drying system to produce solid salt

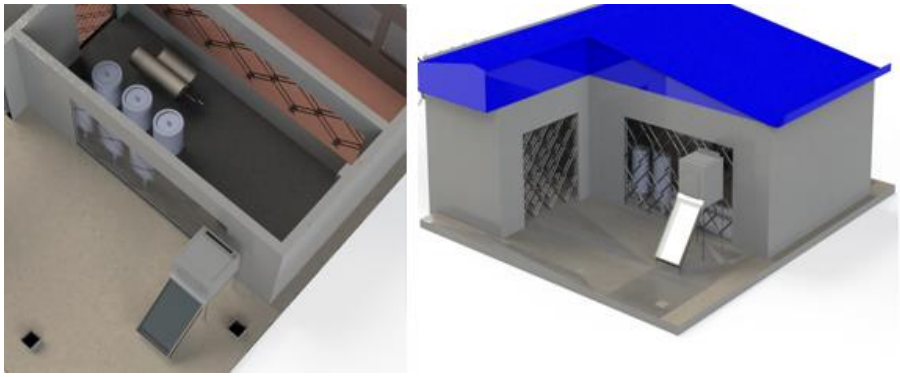

Figure 27: Overall structure of the Desalting system

b) Description of the process steps

Desalting raw hides: desalting is the process of removing the salt sticking to the hide and skin surface by shaking the hides mechanically or manually.

c) Classification unit with sand filter (cloth or mesh)

The dusted salt is prepared as a 12 % solution. The solution is screened to remove hair, tissue, sand, and other insoluble matters. The de-dusted salt after dissolution in water can be passed through a sand filter for the removal of physical and bacterial contaminations.

d) Treatment of salt solution with Aluminum Sulfate

The filtrate is treated with Aluminum Sulfate. When added to a salt solution, aluminum sulfate causes microscopic impurities to clump together into larger and larger particles. These clumps then settle to the bottom of the container and can be filtered out as sludge. This makes the water safer to drink.

e) Reservoir tank

The treated salt solution is pumped to the last processing unit where the cleaner salt solution will appear on the top of the reservoirs and the remaining sludge is collected at the bottom due to density deference.

f) Description and selection of technology

Dedusting of salt from raw hide

About 400 kg of salt is applied per ton of raw hides/skins. While most of the salt penetrates the skin, a substantial quantity remains on the surface. By desalting, it is possible to remove a major portion of this salt.

SALT SHAKER MACHINE: The desalting drum (cage) is primarily made of 316 stainless steel and is rotated by a 15 kW motor. The drum is run at 6 rpm. The raw hides are folded and placed on the conveyor belt. They are subsequently unfolded in the desalting cage and any salt that is stuck to the hides falls off. The desalting process can be timed by modifying the inclination of the drum. The salted hides leave the drum at the rear end. While the transfer time for one hide through the drum varies depending on the inclination, it generally takes about three to six minutes. Ten tones are usually desalted in about two hours.

DESALTING DRUM: Old drums which are no longer used for tanning operations can be converted into desalting drums. This is done by drilling holes of 85 mm diameter at a distance of 130 mm from each other into the surface of the drum and fitting it with a 3.75 kW electrical motor. Wet salted raw hides/skins are weighed and loaded into the desalting drum in loads of 400–600 kg. After closing the door, the drum is run slowly at 3 rpm (velocity 0.35 m/s) for 15 to 20 minutes. The salt loosened from the hide surface drops out of the drum through the holes and collects on the stone floor beneath the drum. After 20 minutes, the drum is stopped, hides unloaded, weighed, and taken for soaking. About 7 to 8 tons of raw hides can thus be desalted in a day.

DODECA WOODEN FRAME: This comprises a dome-type wooden frame with dimensions 0.75 m x 0.75 m x 0.75 m in height. Desalting is performed by holding the hides at the edges and beating them on the frame three times. The salt that falls off is collected manually from the floor. For large hides, four workmen are required; for smaller sides and skins, two workmen are sufficient. On average, it takes two hours to desalt one ton of raw material. This is suitable only for small skins, i.e. goat and sheepskins.

MANUAL SALT SHAKER MACHINE: The saltshaker machine needs electric power. To process ten tones 15 kW of the motor is required. Considering the electric cost in Ethiopia and especially in the study area Modjo, using a Manual saltshaker machine is very crucial.

Table 33 : Comparison of operational parameters in different types of desalting methods

Type	DoDeca Wooden Frame	Salt Shaker Machine	Mechanical desalting drum	Manual desalting Shaker (Selected Option for our case)
Salt Removal	(50-80) kg/ton	(80-100) kg/ton of raw hide	(50 - 70) kg/ton of raw hide	(40 -60) kg/ton
Time taken to desalting one tone of raw hide	120 minutes	30 Minutes	60 Minutes	30 Minutes
Man power requirement	4 Man hours	2 man hours	2 Man Hours	2 Man Hours
Suitability	Skin	Hides	Hides	Hides and Skin

g) Selection of Technology – Dedusting of salt

Technology selection is **a multiple criteria decision-making challenge**. Decision-makers need to consider various characteristics of criteria such as user-friendliness, east to use, maintenance cost, a unique feature, energy-related issues, Innovation, cost of the system, local manufacturability, potential profit, risk, and expenses to identify the most appropriate technologies, etc. The following decision criteria were considered to select the right dedusting machine for our case study. For the technology selection of de dusting machine, the Pugh Analysis was used. The Pugh Analysis or Pugh Concept Selection Process is an iterative process for narrowing down a list of potential product concepts to a single superior concept. Thus, manual desalting machines were selected.

Table 34 : Decision Matrix dedusting Machine - Selection of Technology

Decision Matrix dedusting Machine - Selection of Technology				
Criteria (Rating 1-10)	**DoDeca Wooden Frame**	**Salt Shaker Machine**	**Mechanical desalting drum**	**Manual desalting Shaker**
Cost of components	4	8	8	6
Ease of reproducibility of the component locally	8	6	6	7
Energy use	10	5	5	10
Ease of use	7	10	10	10
Labor requirement	6	10	10	9
Capacity	5	10	10	9
Time taken for overall process	8	9	9	10
Suitability	8	9	9	9
Totals	56	67	67	**70**

h) Capacity of Manual Desalting Machine

1500 kg of dedusted salt will be produced daily using the Manual Desalting Machine as shown in the figure below.

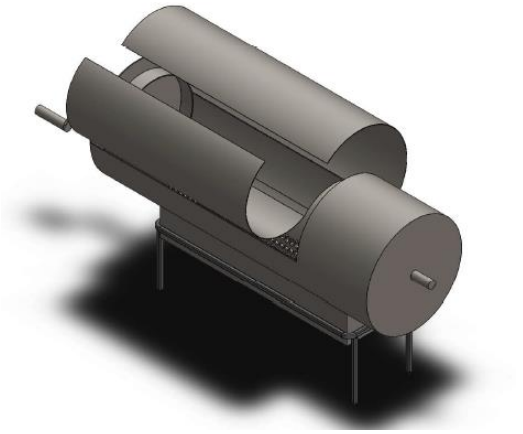

Figure 28 : Manual Desalting Machine

i) Specific Property of Recovered Salt

The specific property of salt recovered by this project is shown in the table below

Properties	Experiment	Control Value
Characteristics of de-dusted salt solution at 7^0Be		
PH	6.32	6.58
^{0}Be	7	7
Chloride (mg/l)	50,242.3	49,708.22
Conductivity (µs)	108.4	108.6
Total Suspended Solid (mg/l)	5178	3969
Total Dissolved Slid (mg/l)	87519	93172
Characteristics of pickle liquor		
PH	3.53	3.34
Chloride (mg/l)	26.69	30.46
Conductivity (µs)	109.5	108.4
Total Solid (mg/l)	90.09	80.3

5.3.3. Market Assessment

a) PRODUCT DESCRIPTION AND APPLICATION

Salt (Recovered salt from Tannery De-salted material)

De-salt recovery from tanneries is used again for the pickling process in tanneries. This process makes the fibers of the hides more receptive to tanning. Pickling refers to the treatment of delimed or bated pelts with a solution of salt and acid to bring them to an acidic condition. The pickling process is primarily conducted to adjust the collagen to the conditions required by the chrome (or any other) tanning reaction. Pickling increases the acidity of the hide to a pH of **3**, enabling chromium tannins to enter the hide. Salt is added to prevent the fibers from swelling. Tannery salt in Ethiopia is widely supplied from the salt resources from the Afar area through salt traders & dealers. Mostly it is packed by 25 kg plastic bag (Polypropylene sack).

Application

De-salted salt from tanneries is mainly used for the pickling process only. It will help add additional quality to the hides in the process of tanning.

b) LOCAL MARKET

Past Supply Trend

The local demand is met through local supplies solely. Accordingly, the major findings of the trend in the past supply of salt is summarized below.

Local Supply

In Ethiopia, a limited number of salt suppliers are engaged in the salt trading business. In this regard, the raw salt is found in abundance in the Afar region but several influential people of the area monopolize the salt supply chain.

It is believed, that during the period 2012-2022; the local supply of salt has increased substantially. According to the Ethiopian Tannery Industries Association consumption of salt was around 350 thousand quintals of non-iodized salt per annum on November 2012. It was difficult to investigate the exact annual consumption of slat for tannery industries in

Ethiopia currently due to a shortage of data. However, according to the survey we conducted the amount of salt consumption currently is around 1,500 tons.

Import

According to our investigation salt has never been imported from outside of our country.

Total Supply or Apparent Consumption

Since there is no record of import of salt observed during the period considered (2012-2021), the apparent consumption or total supply of salt is composed of domestic supply. The market survey conducted indicated that currently there is a shortage of salt supply in the market.

Present Effective Local Demand

There are different approaches for estimating the demand for a product. Quantitative forecasting methods employed for this purpose are generally classified into two categories, time series, and causal. The pattern or behavior of the data in a time series has several components, such as horizontal, trend, seasonal, cyclical, and random (irregular) features. The trend component accounts for the gradual shifting of the time series to relatively higher or lower values over a long period. The data on flexible plastic packaging has a general increasing trend through time. One of the methods used to estimate the present effective demand is the time trend extrapolation method.

However, the production capacity of the envisaged project is only **1,500 kg** per day; according to the market survey, there will be abundant market demand for this amount per day. Especially, the current salt supply shortage in the market is a good opportunity.

Factors That Affect Local Demand of Products Under Consideration

The demand for De-salted salt depends on the performance of the end users. Tannery industries extensively use these materials.

Hence, past performance and prospect of the tannery industry sector determines the magnitude of the demand for salt materials. Accordingly, a thorough assessment of the tannery industries indicates that there is a progressively growing local demand for salt.

c) PRODUCT QUALITY

Product quality is one of the basic and most important marketing mixes that affect the success of a new product. Product quality has two dimensions, i.e., level and consistency.

Level means the producer must first choose a quality level that will be acceptable in the target market and at a level that complies with the quality of competing products. Consistency refers to the consistent delivery of one established quality through strict quality control measures.

Accordingly, the envisaged factory should acquire capable machinery and a safe guarded production process with a system of optimally combined machine operations and control of them by qualified and trained technicians. Besides, quality control should be given top priority especially in selecting of raw material, grade, and process control so that the envisaged factory could achieve its aims by producing the leading quality product.

d) PRICING

A proper quality control system considerably minimizes waste or the rejection of end products and thereby avoids complaints by customers. It also reduces the envisaged factory's operating costs as it facilitates timely corrective measures. Accordingly, the quality control service of the envisaged plant requires a laboratory appropriate for conducting tests of raw materials and final products. Based on the data collected from end users the recommended factory gate price is shown below.

Table 35 : Factory Gate Price of De-Salted Salt (Kg)

Sr. No.	Product Type	Price (Birr)
1	Salt	12

N.B. Price is mostly associated with transportation price.

Table 36 : Average Retail Price for de-dusted Considering Production Costs

Description	Production volume/year	Variable cost per unit	Fixed cost per unit	Total Cost per unit	Assigned price
Year 1	294,000.00	2.94	1.99	4.93	**12.00**

Year 2	315,000.00	2.74	1.85	4.60	**13.20**
Year 3	336,000.00	2.57	1.74	4.31	**14.52**
Year 4	357,000.00	2.42	1.64	4.06	**15.97**
Year 5 & after	378,000.00	2.29	1.55	3.83	**17.57**

For the envisaged project, the recovered salt, which is an intermediate product shall be used for tanneries and it is expected to be directly supplied to the factories that have implemented the salt recovery system. Moreover, it can also be supplied to factories within close geographical proximity located in or around Mojo area.

The envisaged factory is recommended to aggressively advertise its product to tannery industries. Moreover, in a competitive market, trade promotion should be made to persuade or to make a product attractive for end users. The envisaged factory is recommended to offer discounts on the volume of product bought and credit.

e) FINANCIAL STUDY

For this project, the product is expected to be used by the factories that have implemented the salt recovery system. This option is chosen as this is the best viable investment option and the summary of the analysis is presented below. However, the summary of the viability for the other investment options is also presented in the table below for comparison.

Criteria	Independent Investment Option	Establishing the Recovery Plant in the Factory Vicinity
Investment cost in ETB	2,653,741	1,109,477
Total Operating Cost in ETB	2,799,387	1,448,183
Revenue in ETB (Yr 1 & Yr 10)	4,410,000 & 5,670,000	3,528,000 & 4,536,000
Gross Profit in ETB (Yr 1 & Yr 10)	1,110,332 & 1,797,597	1,922,774 & 2,211,061
NPV in ETB	1,110,836.73	5,402,941.27
IRR (%)	11	124
Remarks	The selling price per kg is assumed at 15 ETB	The selling price per kg is assumed at 12 ETB

The financial evaluation takes into account the following assumptions

Table 37 : Financial evaluation assumptions

Criteria	Assumption	Remarks
Production capacity (Kg/day)	1500	
Working hrs/day	8	
Working days/month	26	
Working days/year	280	
Raw material cost including transportation cost (Birr/kg)	0 ETB	
Waste disposal cost (Birr/kg)	0.5 ETB	
Packing size	25kg pp bag with inside lining plastic	
Market segment	Suppliers to leather processing factories	
Product price (Birr/kg)	12.00 ETB with annual price increase of 10%	
Land price and building cost measured in cost of building in ETB per sq.m.	Corrugated sheet on wood frames for building and mortar covered floor finish. For the compound, gravel compacting will be utilized	Land is assumed to be found free of charge.
Raw-material and final product transportation shall be outsourced	10% of the selling price is estimated for transporting the final product to customers.	
Financial Sourcing	70% (Loan) with an interest rate of 11.5% and 30% (Equity from beneficiaries)	
Project life time (Years)	10	
Ideal capacity utilization	A progressively increasing capacity utilization is expected to start at 70% in year 1 and is expected to increase by 5% for the progressive years reaching a maximum capacity of 90% in year 5	

a) Infrastructure

Building and Civil Work

Based on the specification of the envisaged plant machinery and the project's internal requirements, the planned project will construct different buildings, a production hall, service building, input and output store tankers, guard posts, and loading and unloading area, water tanker tower and green area.

The total area acquired for the project is 300 m^2 with an estimated overall construction cost of **490,000** ETB. The overall cost estimation for the construction can be accessed in the annex section below.

Machinery and Equipment

The Investment in machinery and equipment is the major investment item, which determines the production capacity as well as the quality of the output. Utilities

Water Supply

The water source of the project is the local municipal water supply. This source of water is not only important for fresh water used for drink but it is also intended to be used for all sanitation activities of the project.

Electric Power Supply

The project requires about 22KWh of power at full capacity for the production machinery.

b) Plant Capacity and Production Program

The selected machinery was designed for processing a net 1500 kg of recycled salt daily. In the preparation of the production program, it is advisable to consider different factors both from the internal and external factors of production, namely the contribution of the planned and unplanned maintenance downtime, technical knowledge, and time required for technical personnel to acquire adequate experience. Accordingly, considering the level of complexity of the technology, which is moderately medium, and the size of the market demand-supply gap, the capacity utilization is set at 60% in the first year of operation, and 70% in the second year of operation. Following the acquirement of experience in technical, financial, and market factors of the environment, the envisaged plant will operate at maximum capacity utilization (90%) in the fourth year and then after. The detailed Plan of production capacity of the machinery is presented in the table below.

Raw Materials and Inputs

Processing Chemicals, Raw Materials, Packaging Materials & Transportation

The following table outlines the processing chemicals, raw-material, other supplies such as packaging materials, and transportation costs considering the 500kg of net glue production capacity per day.

Table 38 : Processing Chemicals, Raw Materials, Packaging Materials & Transportation

Sr.N	Description	Specification & Units of Measure	Amount/day	Unit Cost (Including transport)	Total Raw-material cost/month
1	Dedusted Salt	Kg/day	1579	0	41052.632
2	Chemicals	Aluminum Sulphate (Kg/day)	30	120	93600
3	Waste disposal Cost	Kg/day	78.9	0.5	1026.3158
4	Packaging material	25Kg Capacity	60	21	1260

Manpower

Based on the planned capacity utilization and production design, the factory will employ 16 skilled, semi-skilled and unskilled individuals and will extend around Birr 672,000 annually for salaries and benefits in the initial year. The list of employees needed for the project is listed in the following table

Table 39: Detail of Manpower requirement

Sr. No.	Position	No. Required	Salary/month	payment per month	Annual Salary
1	Supervisor	1	4,000	4,000	48,000
2	Operators	5	3,400	17,000	204,000
3	Quality control incharge	1	3,000	3,000	36,000
4	Production area cleaner	2	1,600	3,200	38,400
5	Warehouse in charge	1	4,000	4,000	48,000
Aggregate		**16**		31,200	**374,400**

c) Financial Assessment Results

Investment Costs & Source of Finance

The sources of finance for the loan will be long-term loans obtained from local Microfinance enterprises. The total planned investment cost in the initial year is around Birr 2,653,741 of which the financing of the project consists of a bank loan and promoter's equity. Consequently, out of the total investment cost 70% will be a bank loan and 30% will be an equity contribution. The detail of the financing scheme and source of finance is summarized in the table below: -

Table 40: Detail Fund Allocation

Sr. No.	Investment Items	Owner Equity (Birr)	Bank Loan (Birr)	Total Cost (Birr)
1	**Fixed Investment**			
	Main Machineries	70,740	165,060	235,800
	Auxiliary Equipment	24,000	56,000	80,000
	Office equipment & furniture	27,750	64,750	92,500
	Vehicle	3,600	8,400	12,000
	Building Development	147,000	343,000	490,000
Sub-Total		**273,090**	**637,210**	**910,300**
2	**Working Capital**	**53,227**	**124,196**	**177,423**
3	**Pre-Production Costs**			
	Pre-production Cost	6,526	15,228	21,754
	Pre-production Interest	-		-
Sub-Total		**6,526**	**15,228**	**21,754**
Grand Total		**332,843**	**776,634**	**1,109,477**

The above table assumes the investment financing approach considering the leatehr factories as investors. However, depending on the types of business owners (such as: factory owners, private investors or cooperative MSMEs), the ownwers' equity proportion presented on the table above can also be assumed to utilize investment financing options such as lease financing and seed funding.

Working Capital Requirements

Working capital is the amount of money permanently needed in cash or in kind to keep the business operating while it is awaiting full payment for goods sold to customers. The total working capital considered for the project reaches up to 224,802 ETB annually (for the 1st year). It is expected to increase yearly based on the capacity utilization increase. The major cost centers considered in allocating working capital include Local raw materials, Packing materials, Utility Costs, Wages & salaries, Marketing & Promotional Cost, Product Transportation Cost, Work in Progress, Finished Product, Training Cost and other miscellaneous costs have been considered. The total duration of the working capital varies from a cost center to cost center and the detailed working capital allocation is presented in the annex section below.

Revenue & Profitability Projection

The total revenue expected from this project is assumed to derive from the production of recovered salt. During the first year of production, the project will start 70 % of its theoretical production capacity, then every year the project will increase its production performance by 5% until it reaches 90% in the 5th year. Therefore, the projected income is assumed to increase based on the project production performance. The projection for the income statement is primarily derived from market-based sales estimates, which is adequate market assessment and guaranteed sales from previous experiences. The average annual projection of the revenue obtained from the sales of glue is estimated to be Birr **3,528,000** in the first year and expected to grow to **Birr 4,536,000** at the end of the 10th year. The annual net profit to be generated by the company is expected to grow from Birr ***1,922,774*** in its first year to Birr **2,211,061** in the 10th year. The detailed cash flow projections is presented in the annex section below.

Balance Sheet

The Net Capital of the company is expected to grow from about ***Birr*** **1,109,477** in year one to **Birr 10,085,327** by the end of year ten. A detail of the projected balance sheet is attached in the annex part of the business plan. The detailed balance sheet is presented in the annex section below.

Net Present Value & Internal Rate of Return (IRR)

Present Value is one of the discounted cash flow techniques which fully recognizes the time value of money. An investment is viable if the NPV has a positive value and this project has a projected NPV of **Birr 5,402,941.27** considering an annual discount rate of 10%. The Internal rate of return (IRR) is found to be around 124% entailing that this investment is plausible.

Sensitivity Analysis

As shown below, the project can respond well to potential variations in terms of revenue decrease, operating cost & investment increase as the IRR doesn't go lower than 100%. This shows that changes in the const centers under each of the categories may vary with no/ little impact on the business viability.

Table 41: Sensitivity Analysis

	FIRR Before Tax
Revenue Decreased by 10%	>100%
Operating cost Increased by 10%	>100%
Investment cost Increased by 10%	>100%

5.3.4. Health and Environmental Risk and Impact Assessment

If the hide/skin cannot be freshly processed for logistical reasons it is preserved by drying and addition of salts. During the soaking process, the salt will be discharged into the environment. Salt/chlorides mainly emanate from the soaking and tanning stages of salted or brine-cured hides and pickling; they are highly soluble and stable, unaffected by waste water treatment thus making the final, treated effluent unfit for irrigation or livestock watering. At present their treatment and disposal is possibly the hardest challenge for the leather industry in arid regions (Buljan and Kral 2015).

The common salt (i.e., Sodium Chloride) applied to the hides/ skin accounts for 30-45% by weight. It is possible to eliminate up to 10 % of the salt added to hides and skins for

preservation by using hand shaking, mechanical brushes or a suitable drum (Hyderabad 2009). Consequently, this salt can be recovered and used for subsequent processes e,g pickling. Recovery of salt from raw hides/skins involves de-dusting, dissolution, treatment with alum and filtration. Water, chemical (Alum) and energy is used for recovering salt from de-dusted waste.

In the salt recovery system, residues and sludge is generated from filtration and coagulation-flocculation processes respectively account for up to 5% of the input material. Accordingly, approximately of 75 kg of residue/sludge will be generated per day from the envisaged desalting project (LLPIRDC technical study). This shows that there is no significant quantity of waste generated from the waste conversing business. However, the waste should be properly collected/stored and disposed to the industrial waste disposal site.

Regarding OHS, the use of proper PPE and automatic chemical dosing will avoid risks of chemical exposure/spillage and any other emissions from the processes. There is also a need to monitor the corrosion of pipelines and system units.

In general, the salt recovery practice has more environmental benefits than economic values. Some of the positive environmental impacts of the project are listed below

- De-dusted salt if stored in heaps outside the tanneries or dumped in open dumping area is likely to be washed away during rains and causes groundwater pollution (Teklay et al. 2018). Hence, this project reduces the leakage of the inorganic ions to land/water body
- Improve the wastewater quality parameters mainly chloride, TDS, TSS and thus comply with the national effluent discharge limit and buyer's requirement
- Being chloride is highly soluble and stable, it is unaffected by conventional waste water treatment. So, the intervention measure reduces the cost of treatment of wastewater.

5.3.5. Socio-economic Impact Assessment

Utilization of de-dust salt from raw hide/skin on pickling project has a vital socio-economic impact (positive impact) in terms of resource consumption patterns, job creation/income generation, environmental protection & societal health, cost reduction, compliance, etc. In general, tannery industries, unemployed individuals particularly youth, society around Modjo town, and the government will be benefited from such types of businesses. Table 23 illustrates the anticipated socio-economic benefits to be obtained from the salt recovery project.

Table 42: Socio-economic Impact Assessment of Utilization of de-dust salt from raw hide/skin on the pickling process

Indicators/Criteria	Socio-economic benefits
Socio-economic benefit/cost indicators	○ Create job opportunities for 12-20 and 34-42 persons at 46.8% and 100% of bi-product utilization respectively. ○ Additional opportunity for job creation to indirect actors in the value chain ○ Create an opportunity for tanneries to recycle resources which reduces raw material and logistic costs ○ Generates income tax for the government
Environmental and health benefit /cost indicators	• Partly solve the challenges related with the disposal of salt-containing wastes from tanneries • Reduce the quantity of solid waste to be disposal (Approx.420,000kg of de-dusted waste at 95% waste conversion) • Improve the environmental performance of the tanneries in terms of compliance and resource-saving (beam house operation) • Improved public health (reduced level of exposure to pathogens and toxic substances) • Reduce/avoid disposal cost of the waste

In addition, the de-dusted salt recovery project will have the following socio-economic impacts/benefits

- Become part of solutions toward addressing public complaints in the surrounding. Change the perception/attitude of the surrounding communities

- The projects are useful for knowledge and technology transfer for similar waste conversion businesses both existing and new establishments.
- Contribute to developing the skill-base of the future and potential of enhancing stakeholder relation
- In general, enhance solid waste management practices of the tanneries (both national and international requirements) as well as the sanitation and hygiene of the area.

5.4. Project 4: Preparation of Organic Compost from Tannery Fleshing Waste

Limed fleshing is one of the major proteinaceous solid bi-products from tanneries, which is produced in fleshing operations of tanneries. The generated fleshing is usually kept indiscriminately inside or outside of the industrial area, which causes environmental pollution. Composting has been used for the utilization of limed fleshing and it is a better option for solid waste management especially organic solid waste than all other options (Ghosh et al. 2020). Various microorganisms break down organic matter into simpler nutrient-rich products, which are used as fertilizer. It is much better than chemical fertilizer because it is not associated with any kind of risk.

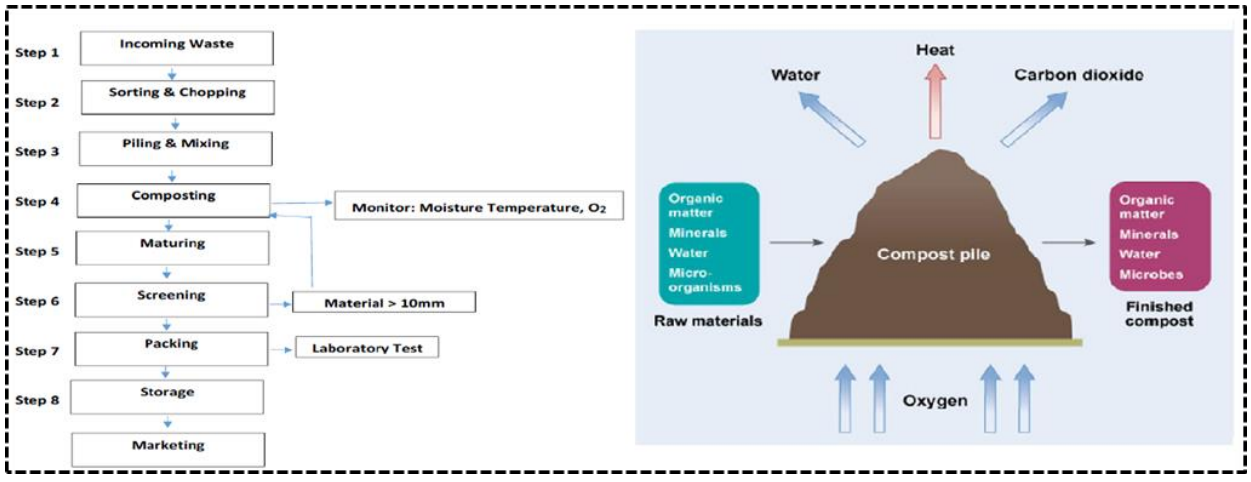

Figure 29: Composting Process

According to the selection criteria for composting technology (Board (CPCB) 2016), the following primary criteria for the selection of waste processing technologies composting must be considered.

Quantity of waste generation: estimating the right amount of tannery waste on a daily, monthly, and yearly basis is important to recommend the right technology for the generated waste. Only about 20 % of the raw skins and hides are turned into leather and the remaining 80 % are discharged as waste (Masilamani et al., 2015). Among the non-leather-making wastes, fleshing is the major hazardous solid waste due to the presence of sodium sulfide, a toxic and corrosive chemical (Bayrakdar, 2020). Fleshing waste is generated during beam house operation. It is collected by the use of waste collection tank. Eventually, it is temporarily stored in the storage area within factory premises. The quantity of fleshing waste generated is 0.2351 kg and 0.3235 per Kg of hide and skin respectively. In other words, 3.6 kg and 0.52 kg of fleshing waste are generated from 1 piece of hide and skin respectively. Assumption: the average weight of hide is 15.31 Kg whereas a piece of skin averagely weighs 1.61 kg (LLIPRDC technical study). Thus, 32,696 kg of fleshing waste per day can be obtained from all tanneries around the Modjo area. Considering 280 working days, a total of 9155 tons per year of fleshing waste is generated around Modjo area. This indicates that there is no challenge in the supply of waste for the proposed project. In general, fleshing waste is one of the most abundant wastes in the tannery industry. Regarding its stability, fleshing waste may create unnecessary odor if it is stored for a longer period. So, it is advisable to collect fleshing waste as soon as possible and transport it using a garbage collector without leakage. The waste can be collected and transported using a municipality tanker. Current practice in Ethiopia shows that fleshing waste is disposed-off together with the municipality wastes. The factory may even pay for the disposal services. Hence, tannery companies are expected to transfer the fleshing waste for free. However, a binding modality could be made between the two entities (tannery & waste collectors) with the understanding that the waste management follows responsible and better disposal technique

Furthermore, new competing businesses may emerge that convert fleshing waste to other valuable products such as poultry feed, Biogas plants, etc that can bring change to the supply and availability, and price of waste.

Amount of other biomass requirements to mix with tannery waste to get compost:

The following inputs(admixtures) are used to prepare organic compost in addition to fleshing waste

a) Wet Biomass
b) Dry Biomass
c) Cow dung
d) Facilitators (loam soil, ash, and old compost)

The ratio of fleshing waste to other admixtures is 1:2 to prepare good quality compost.

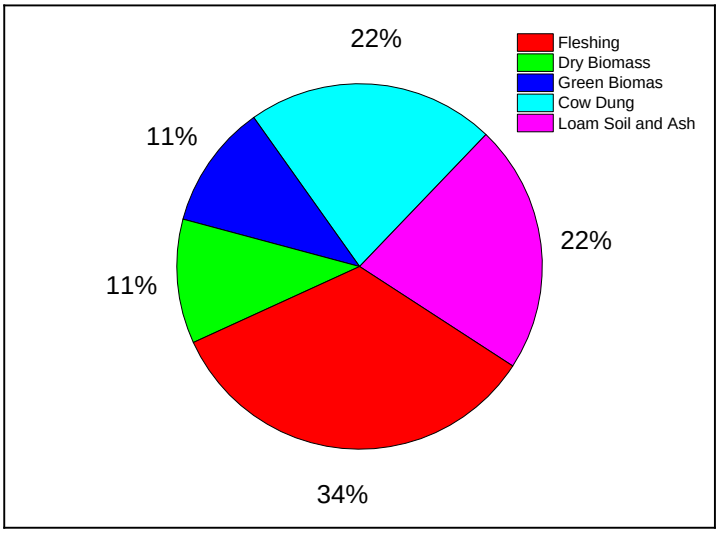

Figure 30: Ingredients to produce compost with the required characteristics

Figure two shows to produce compost with the required characteristics and ingredients, 34 % fleshing, 11 % dry Biomass, 11 % wet Biomass, 22 % cow dung, and 22 % loam soil, ash, and old compost are required. The mixture must be prepared to optimize the composting parameters, affecting their growth and reproduction should be taken into account. These factors include temperature, pH, C/N ratio, oxygen, aeration, and substrate moisture.

Availability of biomass within the proximity of the composting area: As it is highlighted above, to produce compost with the required characteristics and ingredients, 34 % fleshing, 11 % dry Biomass, 11 % wet Biomass, 22 % cow dung, and 22 % loam soil, ash, and old compost are required.

To understand the availability of Biomass within the Modjo area, the land cover map of the area is generated. The land cover map is generated by ESRI and the map is derived from ESA Sentinel-2 imagery at 10m resolution. It shows a global map of land use/land cover (LULC). It is a composite of LULC predictions for 10 classes throughout the year to generate a representative snapshot of 2022. The land use classification based on ESRI is as follows:

- **Water**: Areas where water was predominantly present throughout the year; may not cover areas with sporadic or ephemeral water; contains little to no sparse vegetation, no rock outcrop nor built-up features like docks; examples: rivers, ponds, lakes, oceans, flooded salt plains.
- **Trees**: Any significant clustering of tall (~15-m or higher) dense vegetation, typically with a closed or dense canopy; examples: wooded vegetation, clusters of dense tall vegetation within savannas, plantations, swamps, or mangroves (dense/tall vegetation with ephemeral water or canopy too thick to detect water underneath).
- **Grass** : Open areas covered in homogenous grasses with little to no taller vegetation; wild cereals and grasses with no obvious human plotting (i.e., not a plotted field); examples: natural meadows and fields with sparse to no tree cover, open savanna with few to no trees, parks/golf courses/lawns, pastures.
- **Flooded vegetation**: Areas of any type of vegetation with obvious intermixing of water throughout a majority of the year; seasonally flooded area that is a mix of grass/shrub/trees/bare ground; examples: flooded mangroves, emergent vegetation, rice paddies, and other heavily irrigated and inundated agriculture.
- **Crops**: Humans planted/plotted cereals, grasses, and crops not at tree height; examples: corn, wheat, soy, and fallow plots of structured land.
- **Scrub/shrub**: Mix of small clusters of plants or single plants dispersed on a landscape that shows exposed soil or rock; scrub-filled clearings within dense forests that are not taller than trees; examples: moderate to a sparse cover of bushes, shrubs, and tufts of grass, savannas with very sparse grasses, trees or other plants

- **Built Area**: Human-made structures; major road and rail networks; large homogenous impervious surfaces including parking structures, office buildings, and residential housing; examples: houses, dense villages/towns/cities, paved roads, asphalt.
- **Bare ground**: Areas of rock or soil with very sparse to no vegetation for the entire year; large areas of sand and deserts with no to little vegetation; examples: exposed rock or soil, desert and dunes, dry salt flats/pans, dried lake beds, mines.

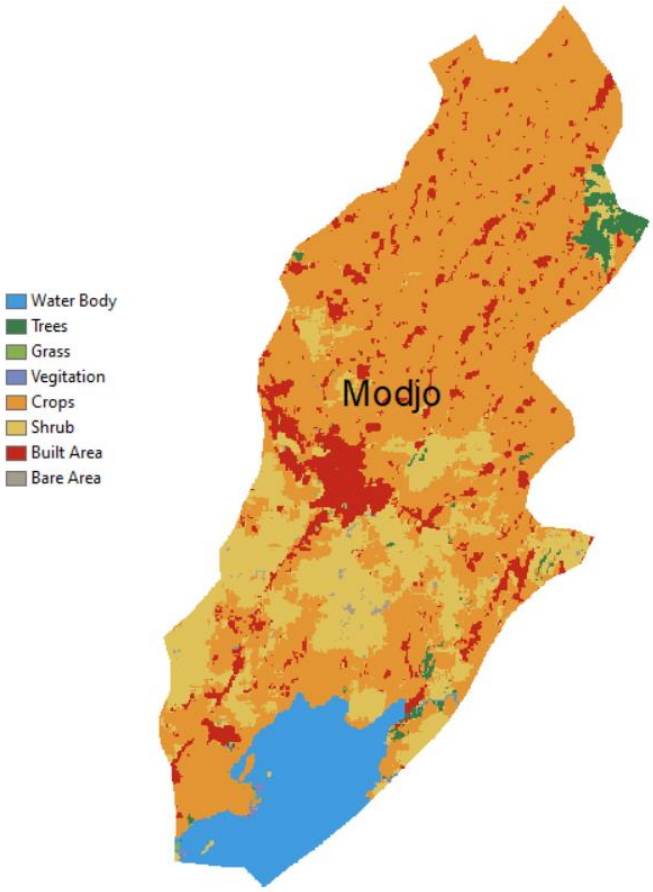

Figure 31: Land cover map of Modjo and its surroundings

Thus, based on the above classification the land cover map of Modjo and its surrounding is prepared as shown in figure 29. As can be seen from figure 29 and table 40, only 1.65 % of the area is covered with the planted tree. There is also a farming activity as farmers plant crops. The area covered by crop planation is 60.9 %. The crop residues are usually used by farmers to feed their cattle. 10 % of the area is covered by building area and naturally found and season shrubs account for around 18 %. It is extremely hard to collect

those shrubs. On the one hand, they are very seasonal and on the other hand, they are growing in a scattered manner and are hard to collect. The Google earth View also shows the biomass extents of Modjo and its surrounding as shown in figure 30.

Table 43: Area coverage and percentage class of land cover of Modjo and its surroundings

Land Cover Class	Area in km^2	Percentage
Water	0.6655	9.536
Trees	0.1135	1.626
Grass	0.0067	0.096
Vegetation	0.0073	0.105
Crops	4.2504	60.904
Shrubs	1.2822	18.373
Built Area	0.6349	9.098
Bare Area	0.0183	0.262
Total	6.9788	100

Figure 32: Google Earth View of Modjo and its surrounding

Figure 29, table 40, and figure 30 show that it is extremely hard to find other biomass within proximity in large amounts throughout the year around the Modjo area. Based on the data obtained from tanneries around the Modjo area, around 9,155 tons of hiding and skin fleshing per year can be obtained from all Tanneries around the Modjo area yearly. Thus, to produce compost using the available fleshing waste, 2,962 tons of dry biomass(and 2,962 tons of wet biomass must be obtained. Dry biomass includes fallen leaves, dried grass and wood chips where as fresh/wet grass clippings, and fresh leaves

is considered green biomasses. As can be seen from Figures 29 and 30, it is impossible to get that wet and dry biomass from Mojdo and its surrounding area. Besides, there is also a huge logistic cost to bring that Biomass from other locations.

To understand the amount of cattle dung that can be found in the Modjo area, data has been collected. Data from the livestock population of Lume District shows that there are 130,855 cattle in the district. Modjo is the capital city of the district. With the assumption of 4 kg of dung per one cattle head per day, 25% of collection coverage, 47,762 tonnes of dung can be obtained yearly around the Modjo area. On the other hand, 5,924 tonnes of dung is required yearly to produce compost using the available fleshing waste from tanneries. Even if there is no shortage of cattle dung in the Modjo area it is hard to collect all those dung for the intended purpose because of the open grazing practices of the surrounding and logistical issues. It is also impossible to collect the cattle dung from the dairy farms around the town. This is because the dung is being used by the farms and the communities nearby the farms for different purposes mainly as fertilizer/soil conditioner.

Furthermore, the fact that the admixtures such as dry biomass and dung have multiple uses brings change to the supply availability and price of the input materials. For example, dry biomass is used locally as animal feed and cow dung is used as a local energy source and construction material by the farmers. Moreover, since the potential organized sources of these inputs, such as cattle farms (not that may in number and with only around 200-300 cattle head counts) are not found close to the planned project area, also poses a challenge in the form of logistic cost, which can reach up to 1ETB per kg of material. In addition, the animal dung is also used for local energy sources by the established cattle farming businesses using local biogas plants.

Associated cost to get additional biomass and other inputs to the composting area: transporting, handling, and storage of fleshing waste from tanneries and other required Biomass, cow dung, loam soil, and ash must be carefully considered. Based on the data collected from tanneries and site visits to the area, there are no wood manufacturers around the Modjo area, and collecting 22 % of cow dung from different farmers scattered widely in the Modjo area is difficult from a logistics point of view.

Characteristics of waste: The variation of waste varies through the year both in terms of amount and in terms of characteristics creating a difference in the generated compost quality.

Time required completing one batch of compositing: composting process lasted for more than three months to get one batch of compost product. However, the amount of waste generated from tanneries is daily and storage issues must be given the highest priority. Microbial bacteria can be introduced to reduce the composting time. Besides to speed up the composting process, it is good to make a larger pile, prepare proper ratio of brown materials to green materials, shred everything, aerate it properly and keep your pile moist.

Land availability: the required amount of land must be secured and the investment cost of getting the land is very crucial for the success of the compost project. In this regard, the fact that one batch of production of compost requires 96 days, implies that there is a need for vast area of land to account for consistent and successive production cycles.

Prevailing environmental conditions: The principal environmental factors of interest in composting are temperature, pH, aeration, moisture, and substrate (i.e., availability of essential nutrients). One of the most important aspects of the total nutrient balance is the ratio of organic carbon to total nitrogen (C/N). A C/N in the starting material of about 25 - 30 is optimum for most types of waste. Composting is a bio-oxidative microbial degradation process of mixed organic matter. This exothermic composting process produces a relatively large quantity of energy. According to research (Diaz et al. 2007), only 40–50% of this energy can be utilized by microorganisms to synthesize; the remaining energy is lost as heat in the mass. This large amount of heat causes an increase of temperature in the mass and can reach temperatures of the order of 70 - 90^{o}C.

Climatic conditions: The optimal peak temperature for aerobic composting is 55 to 60 degrees Fahrenheit, which occurs when aerobic macro- and microorganisms are breaking down compost inputs and reproducing at a fast rate. This high temperature also kills any lingering bacteria or weed seeds.

Market natute: The market for organic compost is not yet established as the only potential customers found are small scale plant sellers around Bishoftu area. And these businesses normally produce their own local organic compost. Our survey also showed that the price organic compost is sold by these businesses varies between 80 and 280 ETB per kg entailing that the market price and the standard compositions of such a product is yet to be standardized. Organic compost mostly prepared in the back yards of farmers for their own consumption.

Other factors to incorporate while selecting composting projects also include social acceptance, the market for the products, capital investment, siting criteria, and Environmental norms.

Composting has huge benefits: Enriches soil, helps retain moisture and suppress plant diseases and pests, Reduces the need for chemical fertilizers, and Encourages the production of beneficial bacteria and fungi that break down organic matter to create humus, a rich nutrient-filled material. However, the profitability of the compost business from tannery waste especially in Modjo areas is very challenging. In conclusion, compost production from fleshing waste is not a promising business in Modjo area due to the following reasons

- Supply limitation of admixtures (dry and green biomass, animal dung, saw dust & loam soil). There is high demand for sawdust from particle board & MDF manufacturing companies which makes the competition fierce
- Difficulty of collecting and transporting the admixtures which accounts for 66 % of the total input material. Raw material for compost doesn’t have well-established supply chain and coordinating all the raw material supplies will need great deal of supply chain expertise and coordination
- It takes long duration of time to generate the compost by the indicated process sequence which entails that to maximize production consistency and volume a large area of composting land is required.
- There is a better business alternative to utilize fleshing wastes with better economic viability such as the production of energy using biogas with potential additional products such as fertilizer, as well as, heat energy.

- Increase logistic costs related with transporting fleshing waste itself, admixtures as well as a final product since large quantity is being used.
- The capacity of the planned MSMEs in handling such a complex value chain of multi-stakeholders can also be a major challenge.
- There are local uses for the inputs such as cow dung, which is mostly used as a household firing & biogas so it is not abundantly available in the market. In this regard, dry & biomass or their substitution is mostly used for cattle feed
- Organic compost does not have standard preparation, composition, and quality.

Instead of producing compost using 66 % of additional inputs (wet and dry biomass, sawdust, a large amount of cow dung, load soil and ash, and old compost), Biogas production using hide and skin fleshing is very promising as the Biogas produces electricity, heat as well as fertilizers. According to the European Biogas Association report (Gomez 2013), Biogas starts being acknowledged worldwide as the most upfront technology for upgrading waste to valuable fertilizer and renewable energy. This success relies on several key advantages (Gomez 2013):

- Biogas is directly applicable in numerous sectors such as heating and cooling, in electricity production, transport or even in the chemical industry
- The biogas production process is mature and resilient: it can make use of a great variety of substrates
- Biogas is an 'all-rounder': it can provide energy all year long with no intermittency
  • Biogas is a silver bullet in agriculture for mitigating methane emissions, the second most harmful GHG after CO_2
- Biogas turns organic waste and residues into valuable products, allowing for nutrient recycling and energy production locally

Estimation of Biogas production from hide and Skin fleshing around Mojo areas: Based on the data obtained from tanneries around the Modjo area, around 9,155 tons of hiding and skin fleshing per year can be obtained from all Tanneries around the Modjo area.

Table 44 : Preliminary Estimation of Biogas Production from Biogas production from hide and Skin fleshing around Mojo areas

Hide and Skin Fleshing	Amount	9,155 tons/year
Feedstock	Dry matter	20% FM
	Volatile solids	96.7% DM
Technical		
Annual Operating hours CHP for base load	[h/a]	8,000
Biogas Production	1,770,000	m^3 / year
Methane Production	1,130,000	m^3 / year
Sellable Volume of Digestate	9,264	m^3 / year
Plant Components		
Storage		
Concrete Area	[m^2]	40
Pretreatment		
Sanitation	[m^3/a]	15,258
Shredder	[m^3/a]	15,258
Feeding		
Direct feeding by screw conveyors	[t/d]	25
Wheel loader	[t/d]	25
Digester		
Digester Size	[m^3]	1,800
Stirring		
Long-shaft agitator	[pieces]	3
Paddle agitator	[pieces]	1
Gas storage		
Internal Gas-Hood	[m^3]	1,600
Digestate Storage		
Tank	[m^3]	178
Gas Cleaning		
Desulfurization with air	[m^3 Biogas / h]	2,223
Gas Utilization		
Electric Power	[kWe]	659
Heat	[kWe]	781
Technical Results		
Production		
Total electricity production	[MWh/a]	5,272
Total heat production	[MWh/a]	6,248
Specific energy output of feedstock	[kWh/t FM]	1,217
Minimum as % of maximum gas production	[%]	100%
Self-consumption		
Electrical self-consumption	[MWhe/a]	380

Electrical self-consumption	[% of prod.]	7.2
CO2eq-avoidance	[t CO2eq/a]	791

Based on the primary assessment of Biogas plant performance estimation, using 9,155 tons of fleshing waste, the system generates 659 Kw of Electric power, 781 kW of heat and 9,264 m^3 year of digestate for fertilizers. As the system also avoid, it is possible also to get additional revenues as carbon credit as the system avoids 791 tons of CO_{2eq}. Thus, the Biogas plant operator can get revenues from the following electric power, heat, digestate, and carbon credit. The electric power can be used by the tanneries around Modjo town. This is a win-win solution for the tanneries as well as the plant operators. In the compost case, only one product is obtained and in the biogas case, four high-value and sellable products are obtained. Thus, it is highly advisable to focus on Biogas production from hide and skin fleshing than composting.

Hide and Skin fleshing as a poultry feed: The poultry industry is gradually increasing in Ethiopia and imported and costly protein concentrates are used in formulating the poultry diet. Hide and skin fleshing is rich in proteins and lipids. The main components of Poultry Nutrition are Water, Carbohydrates, Fats, Proteins, Minerals, and Vitamins. Thus, as Hide and skin fleshing's contain protein and fats, they are useful ingredients to prepare poultry feed. The main procedure to prepare poultry feed is the hide and skin fleshing are washed and heated with water to remove any contaminant from the flashings. The boiled fleshing is dried, grinded and ready to be mixed with other ingredients. Based on data around 9,155 tons of fleshing waste can be obtained around Mojo areas. Based on the data collected from the Ethiopian livestock institute, the number of chicken pollution is depicted in table 42. It has to be noted that the main city of Lume Woreda is Mojo. Thus, there is a potential market of poultry feed if we combined the hide and skin fleshing with other ingredients. The generated poultry feed can be also be distributed to other areas as the cost of poultry feed is very high in Ethiopia currently

Table 45 : Basic production data for poultry (Meat), Lume Woreda

Basic production data for poultry (Meat)							
Region	**Woreda**	**Indigenous: Total number of chicken population for meat in 2009 E.C**	**Indigenous: Total number of chicken population for meat in 2010 E.C**	**Indigenous: Total number of chicken population for meat in 2011 E.C**	**Cross Breed or Hybrid: Total number of chicken population for meat in 2009 E.C**	**Cross Breed or Hybrid: Total number of chicken population for meat in 2010 E.C**	**Cross Breed or Hybrid: Total number of chicken population for meat in 2011 E.C**
		#	#	#	#	#	#
Oromia	**Lume**	70000	24,700	32570	19000	14,565	28000

General remarks on production of compost from fleshing wastes/bi-products project

1. Technical studies should be conducted for alternative projects for fleshing waste valorization i.e biogas generation and production of poultry feed from the intended waste. Central biogas plant or individual biogas plants can be stablished by each tannery factories for the project. In case of production of poultry feed, any investors or MSMEs may engage in the waste conversion project.
2. There will be a probability to make available the fleshing waste to the existing and emerging compost production businesses for the purpose of solving the environmental concern of the wastes. The business owners for this project may be farmers, MSMEs, dairy farms, animal fattening companies etc., which can easily get one or more admixtures.

5.5. Project 5: Brick production from tannery effluent sludge and clay

Tannery solid waste represents one of the burdensome environmental problems owing to the enormous quantities of discarded material besides the toxicity of the Tannery sludge is an unavoidable by-product of wastewater treatment plants of leather industries and with no safe disposal options (Teklay et al. 2017). Chromium-rich tannery sludge (TS)

generated from the effluent treatment plants of the leather industry has the potential to contaminate soil, surface water, and groundwater and pose a threat to the environment and natural resources if it is not disposed of properly. Sludge from tannery effluent treatment plants in Ethiopia has been categorized as hazardous waste due particularly to the presence of chromium in it. Usually, about 100 - 150 kg of sludge is generated per ton of hides/skins processed which is composed mostly of chemically precipitated dissolved chromium. (Kavouras et al. 2015) highlighted that Tannery sludge (TS) contains elevated concentrations of heavy metals like Cr, As, Ni, Co, Cu, Zn, Fe, Cd due to the use of basic chromium salt, dyes, pigments, tanning agents, etc. in the tanning process. Several studies have shown that tannery sludge can be effectively stabilized in construction materials such as concrete, ceramic tiles, and other engineering materials.

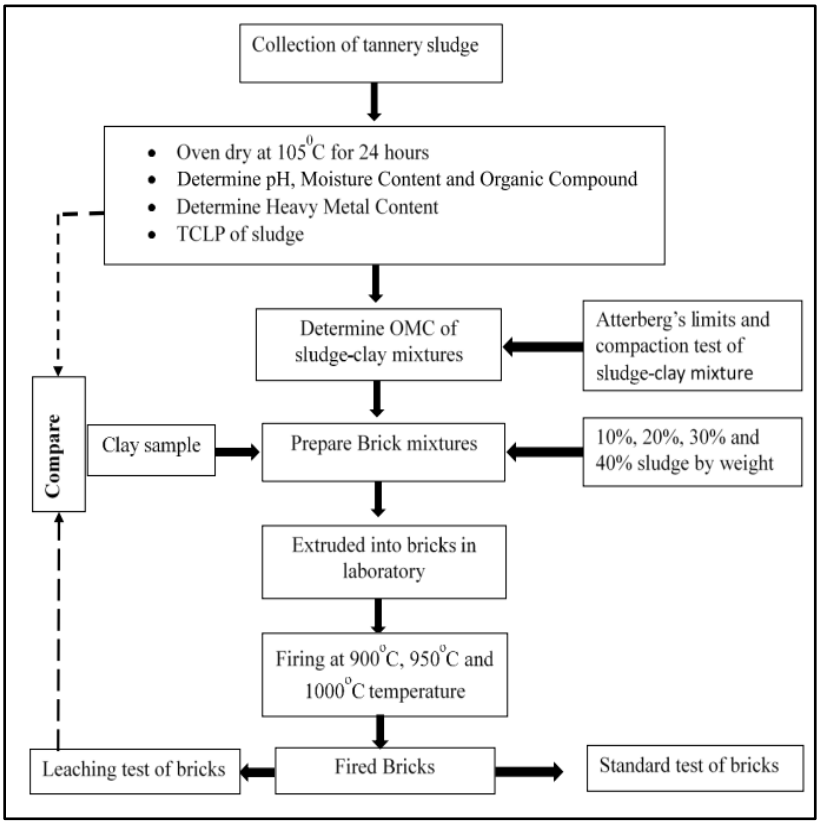

Figure 33 : Methodology to produce Bricks from tannery Sludge and Clay (Dweck et al. 2000)

According to the UNIDO report (Hauber and Buljan 2000), the commercial practice for preparing bricks from tannery sludge involves the following principal steps:

- The wastewater is treated with a coagulant (aluminum sulfate) with continuous stirring; pH was adjusted to 8-9 and kept for several hours (up to 12 hours) so that the sludge can settle down.
- After the sludge settles down, this liming sludge will be collected and it will be sun-dried for 72 hours to remove excess moisture.
- Ground clay will be collected and it will also be sun-dried for 72 hours.
- Then both liming sludge and clay will be oven-dried for 24 hours at 105c.
- The dried raw clay and liming sludge will then be grinded and mixed with water in various compositions (preferably between 4%-7% of liming sludge for every batch).
- Characterization of wastewater is the key step for taking the initiative to manage wastewater released from the liming process.
- The pH of the liming water is usually greater than 10, or around 11 due to the use of lime which was necessary for the operation.

According to the UNIDO report (UNIDO 2020), Physically the bricks produced with the following mixture gave the best results (listed in rank order, best on top).

1. Wet sludge + brick clay + sand
2. Pulverized sludge + cement
3. Pulverized sludge + brick clay + fly ash
4. Pulverized sludge + brick clay
5. Pulverized sludge + clay soil
6. Pulverized sludge + fly ash + lime
7. Wet sludge + wastes from the ceramic industry

Ariful Islam and Al Mizan conducted a study along with the Committee for Advanced Studies and Research (CASR), BUET, Bangladesh, and the NGO FORUM for Public Health. The findings of their study indicate that by incorporating tannery sludge, it is possible to produce high-quality bricks that meet all of the required mechanical and physical properties as specified by ASTM and BDS standards, with little concern for

toxic metal leaching into the environment. Ghonaim and Abadir conducted research on the Use of Tannery Solid Waste in the Production of Building Bricks with Rubiky leather city in Badr City, Egypt, with the goal of making use of an environmentally unfriendly waste and reducing the amount of clay used in the process. For each batch, waste sludge was added up to 5 % with 15 % water, and the brick was fired to 700°C, where the strength values were compared to the minimum allowable strength according to ASTM C62/2017. They concluded that the use of waste sludge as an additive to clay brick has both economic and environmental benefits because it utilizes polluting waste. (Giugliano and Paggi 1985) a study has shown that tannery sludge can be used in brick manufacture for up to 10 % of the dry weight of bricks. Bricks containing sludge are higher in porosity than controls. Bending strength and frost resistance are acceptable at 10 % but are decreased below acceptable levels in bricks made with 15 % sludge. Thus, the maximum tannery sludge that has to be added is 10 %. This study is in line with the experimental work of the Leather Industry Development Institute (LLPI-RDC), Ethiopia.

One of the important criteria for the success of the Brick business to understand the easy availability of other materials for brick production. In general, the brick can be prepared (UNIDO 2020) using wet sludge mixed with brick clay and sand, pulverized sludge mixed with cement, pulverized sludge mixed with brick clay and fly ash, pulverized sludge mixed with brick clay, pulverized sludge mixed with clay soil, pulverized sludge mixed with fly ash and lime and wet sludge mixed with wastes from the ceramic factory were tried.

Considering the Modjo area, there are no challenges in getting the sludge from tanneries. Sludge is generated from both chemical and biological treatment processes. It is sludge obtained from the biological sludge that can be mixed with clay soil to produce bricks.

Current practices in Ethiopia show that sludge from a tannery is stored in the open air and transferred to the external vendor without any treatment for off-site disposal. However, it needs further moisture removal and size reduction to make the waste appropriate for the intended purpose.

Regarding the reliability of waste supply, sludge is available every month as long as tannery production is undertaken. The quantity of sludge generated may vary based on the attainable production capacity of the tanneries. In summary season, it is difficult to dry the sludge which will affect its suitability for the intended purpose i.e brick production. However, brick production is also difficult this season.

Even if different attempts were made to convert tannery sludge into valuable products, such solid bi-products from tanneries are not yet consumed by any waste-converting businesses which in turn signifies its unlimited availability. Current practices in Ethiopia shows that sludge is disposed of by external vendor which may request service fee from the tannery industries. Moreover, there are no other application areas utilizing sludge that bring change to the supply availability and price of sludge. Hence, tannery companies are expected to transfer the sludge for free.

The generation rate of sludge from the tanneries in the study area/Modjo town is estimated to be 11,145 – 16,718 kg/day of which 3,344-5,015 kg/day is biological sludge with the assumption that 30% of the total sludge is a biological one.

As it is highlighted in the above section, to get a good quality brick, the amount of sludge to be added should not be more than 10 %. This implies that the remaining inputs (clay soil) must be obtained from other sources within proximity. Hence, it is not logical to establish a new business producing bricks based on the reliable availability of 10% of the waste/sludge in the area. If this is the case, the business owner can work with the existing brick producer in supplying tannery sludge as a supplementary/alternative raw material.

Due to this fact, the business case of brick production from tannery sludge around the Modjo area is evaluated by taking into account the above assumption and the results of the evaluation are described as follows;

1. There is no brick producer around Modjo area. The Burayu brick factory is located at 90Km from Modjo town, which probability utilizes the sludge as input raw material. The factory has its quarry site for the clay soil supply at nearby proximity.

Hence, it becomes costly to transport sludge between the two cities. Estimation amount per kg of waste?? That is going to make the business not profitable.

2. There may be no clay soil around Modjo area where we need more than 85 % of clay mixture to produce bricks.
3. The MSMEs only induce less value addition to the waste conversion business. The role of business owners is only limited to drying and size reduction processes in addition to transporting the input raw material. These operations even incur an additional cost which will affect the financial viability of the project. Moreover, it may not be comfortable for the external entity to get into the tannery industries to accomplish the intended tasks.
4. The bricks factory also manifested limited willingness to use the sludge for production due to the associated odor of sludge as evidenced by LLPI-RDC and brick company itself.
5. Other factors such as the quantity of sludge to be supplied, final product safety(leachate) etc can probability influence the proposed project.
6. The basic raw material for brick manufacturing is clay, which is freely found in the areas of brick manufacturing companies
7. There is a demand of very high temperature which is more than 900degrees which will need a high energy source and the brick manufacturing machinery cost is considerably high
8. Current market survey conducted on the construction sector indicated that the overall demand for brick is decling from time to time

In conclusion, brick production from tannery sludge is not feasible in Modjo area due to the aforementioned reasons concerning raw material supply, logistic/technical, financial, environmental & OHS assessments.

The other promising option to utilize the sludge from tanneries is the production of Biogas. It has to be noted that there is a biogas plant constructed by Dr. Andualem Mekonnen, Center for Environmental Sciences, Addis Ababa University with SIDA support at Modjo tannery as shown in the figure below.

Figure 34 : Biogas Plant at Modjo Tannery (Constructed by Dr. Andualm Mekonnen, AAU)

As it is highlighted above, the generation rate of sludge from the tanneries in the study area/Modjo town is estimated to be 11,145 – 16,718 kg/day of which 3,344-5,015 kg/day is biological sludge with the assumption that 30% of the total sludge is a biological one. This gives us annual sludge generate a rate of 98 tones per year.

Estimation of Biogas production from sludge-generated tanneries around Modjo areas: Based on the data obtained from tanneries around the Modjo area, around 98 tons of sludge per year can be obtained from all Tanneries around the Modjo area.

Table 46 : Preliminary Estimation of Biogas Production from Biogas production from sludge-generated tanneries around Mojo areas

Hide and Skin Fleshing	Amount	98 tons/year
Annual Operating hours CHP for base load	[h/a]	8,000
Biogas Production	390,000	m^3 / year
Methane Production	250,000	m^3 / year
Sellable Volume of Digestate	842	m^3 / year
Plant Components		
Storage		

Concrete Area	[m²]	10
Pretreatment		
Sanitation	[m³/a]	1,960
Shredder	[m³/a]	1,960
Feeding		
Direct feeding by screw conveyors	[t/d]	3
Wheel loader	[t/d]	3
Digester		
Digester Size	[m³]	400
Stirring		
Long-shaft agitator	[pieces]	3
Paddle agitator	[pieces]	1
Gas storage		
Internal Gas-Hood	[m³]	400
Digestate Storage		
Tank	[m³]	16
Gas Cleaning		
Desulfurization with air	[m³ Biogas /	48
Gas Utilization		
Electric Power	[kWe]	126
Heat	[kWe]	148
Technical Results		
Production		
Total electricity production	[MWh/a]	1,011
Total heat production	[MWh/a]	1,185
Specific energy output of feedstock	[kWh/t FM]	2,057
Minimum as % of maximum gas production	[%]	100%
Self-consumption		
Electrical self-consumption	[MWhe/a]	79
Electrical self-consumption	[% of prod.]	7.8
CO2eq-avoidance	[t CO2eq/a]	107

Based on the primary assessment of Biogas plant performance estimation, using 98 tons of sludge, the system generates 126 kW of Electric power, 7148 kW of heat, and 842 m^3/year of digestate for fertilizers. As the system also avoids sludge waste, it is also possible to get additional revenues as carbon credit as the system avoids 107 tons of CO_{2eq}. Thus, the Biogas plant operator can get revenues from the following electric power, heat, digestate, and carbon credit. The electric power can be used by the tanneries around Modjo town. This is a win-win solution for the tanneries as well as the plant operators.

5.6. Project 6: Preparation of Leather Board From Chrome Shavings

Preparation of leather boards from chrome shavings waste is economical and helps in reducing the environmental pollution. The process for the preparation of leather boards involves soaking chrome shavings in mild alkali, processing in a mincer, and mixer addition of rubber latex and other chemical required and diluted to 5 % with water and passing through a nylon mesh and applying vacuum to get wet leather board. These wet boards are pressed in a hydraulic press to remove excess water and dried to get leather boards. These boards are later calendared and stored. These boards are ready for use. The unique feature is that the process provides an eco-friendly as well as economical option to utilize tannery chrome shavings, which would otherwise add to disposal problems, into a value-added product, thereby creating value addition and utility for a byproduct of the tannery.

As highlighted by LLPIRDC research outputs (Teklay et al. 2017), preparation of leather board and regenerated leather from chrome shaving waste and finished leather scrap is a promising solution to change chrome shaving waste into an opportunity. To enhance the mechanical properties of the produced leather board, plant fibers must be incorporated. According to (Senthil et al. 2015) plant fibers improve the mechanical property of leather composite material. Thus, by mixing fiberized finished leather scrap with plant fibers in various proportions, it is possible to produce high-quality leather board. Different researchers also produced leather boards by mixing different plant fibers coconut, sugarcane, banana and corn silk with finished leather scraps. Leather composites materials are a promising solution for the preparation of footwear materials and leather goods (used as a reinforcement material). In addition to its cost, it is also used to reduce environmental pollution (Senthil et al. 2015) . Preparation of flexible composite sheets made from dyed trimmings and in combination with natural fibers in various blend ratios of wastes from jute and cotton as sources of natural fibers shows good mechanical strength property. (Teklay et al. 2017) highlighted that leftovers from leather product industries can be used to prepare composite sheets as shown in figure 1. (Haile 2018) performed experimental work on producing leather board by Incorporating plant fibers into leather board preparation enhances its mechanical properties. Fiberized chrome

shaving waste mixed with the plant fibers in various proportions (10, 20 and 30%) were used to prepare composite leather board.

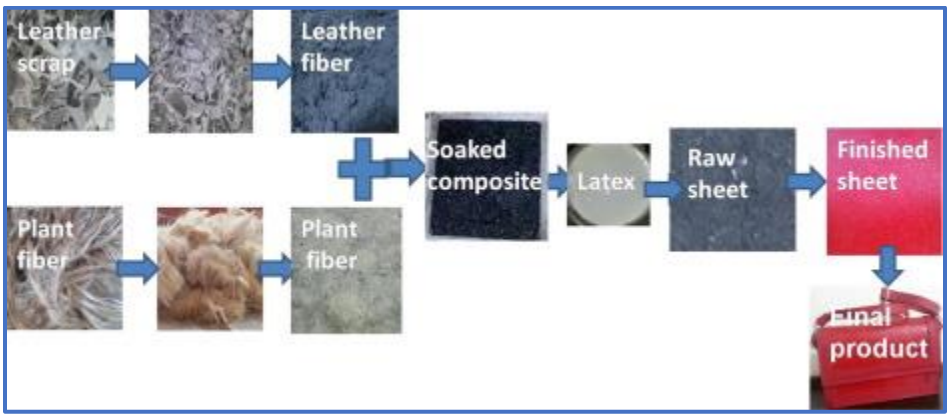

Figure 35 : The flow diagram of making composite sheet (mixture of leather fiber, plant fiber and binder).

Different researcher also produce leather board from chrome shaving waste and mixing with different kinds of waste (Kibet et al. 2022).

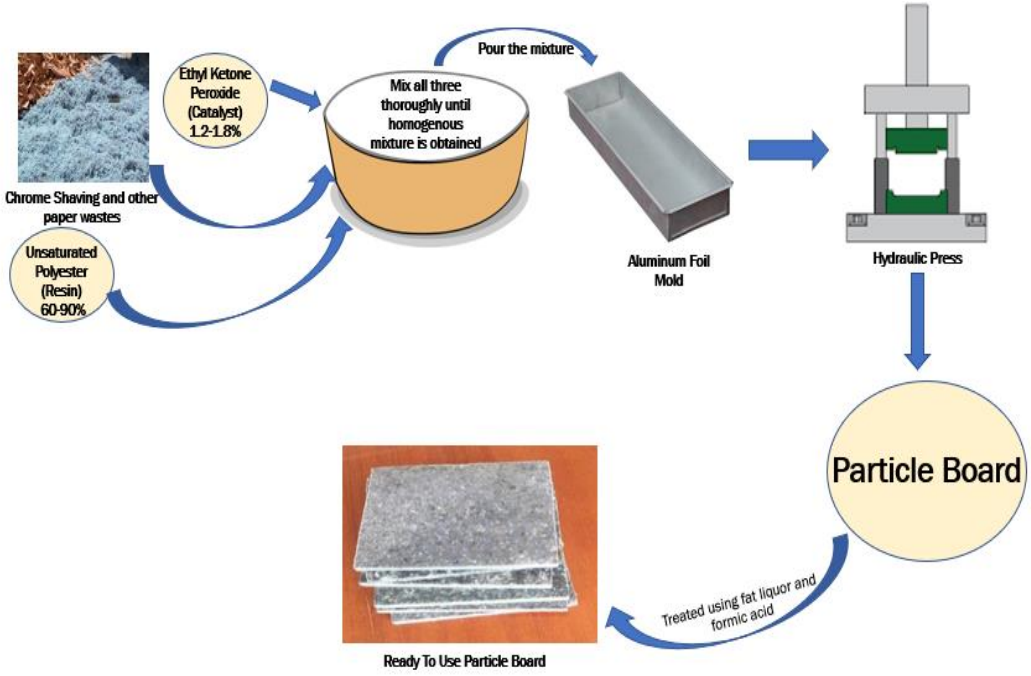

Figure 36: Production of particleboard from chrome shaving and paper waste (Kibet et al. 2022)

According to the research output of LLPI-RDC, the product mix to produce partition board (Wall partition) 70 % sawdust and 30 % chrome shaving must be used to get high-quality particleboard that fits the standard. But for other kinds of high-quality boards, 90 % sawdust, and 10 % chrome shaving. Thus, based on the LLPI-RDC research output, an average of 20 % of chrome waste and the remaining 80 % is sawdust. To produce particleboard, a high-pressure pressing machine (around 200 bar), heating source (around 120 Degree centigrade), and resin is needed.

Considering the Modjo area, there is no problem with getting chrome-shaving waste freely. However, there is no wood manufacturing industry around that area to bring the 80 % ingredient to produce particleboard. There two plausible options to proceeds with this business idea are:

1. Delivering the chrome shaving bi-product to existing sawdust particleboard manufacturers in Modjo area.
2. Adopting small scale system to produce small size chrome shaving particle board Manufacturing locally small-scale pressing machine for producing the particleboard by mixing with saw dust could be possible. In this case, the size of the particle board will be small.

Reflections on option 1:

In this regard, for the one part, the closest business is found in Dukem entailing additional logistic cost to transport. On the other hand, there is would be no feasible bargain power for the leather bi-product supplier as there are associated drawbacks of odor and leachate formation on final products that the existing manufacturers are concerned about.

Reflections on option 2:

This process requires that a state-of-the-art and complex particleboard manufacturing process and facility is established to account for the stringent product quality requirements, which entails a huge initial investment. In this regard, the other option that can be explored is investing in a small-scale particleboard process. The logistic cost of bringing sawdust to Modjo town can be substantial with an estimated cost of 1ETB per kg of weight. Moreover, the fact that there are big players in the particle board manufacturing

sector also entails a competitive market for accessing sawdust. To account for the high investment cost of this option, a locally designed and manufactured small-scale system with the capability of producing small-sized particleboard can also be explored. However, the quality of the dimensional accuracy and the surface finish may not be guaranteed, as the actual process requires a controlled temperature (around 300 degrees) and pressure (200bar) applications for ensuring high-quality products. Moreover, the selling price of such particle boards is found to be not more than 50ETB per unit size, which may not be economically viable considering all the fixed and variable costs if establishing and running such a business.

Figure 37 : Small-scale pressing machine for producing the particleboard

1. The current size demand for particle board is 1.22 m width, 2.44 m length by 8, 12, 13, 16, 25 mm or more thickness which will be very hard to produce with small scale manufacturing facility
2. The product is sometimes required to be laminated with fine sawdust also, which requires sophisticated process and quality control.
3. The raw materials are wood block, sawdust & glue; which are not available in abundance & there is a huge local market competition
4. There is also a restriction on tree cutting & transportation of wood blocks in the country

5. The particle board manufacturing machinery cost is considerably high
6. The manpower required for the sophisticated nature of this product is high end & there is no abundant qualified experts in this area in our country's manpower market

Fabrication of Regenerated Leather Using Chrome Shavings as Raw Materials: Several companies in developed countries are preparing Regenerated leather billet (semi-finished product) using hot pressing and chrome shaving and environment-friendly polymer waterborne polyurethanes resins as input material. The chrome shaving waste is mixed with resin and water based on their proportion. Then the mixed inputs are put into a mold to get the required shape and pressed by a hot-pressing machine at a temperature of 100°C under a pressure of 12 MPa for around 3 min, followed by a press treatment at room temperature for 2 min. Based on the findings of (Cuicui et. al, 2017), the regenerated leather has high tensile strength, good thermal stability, and high heat storage ability.

Sastry et al. (2005) have prepared regenerated leather consumer products from chrome shavings waste like key holders, light hand bags, and wallets using leather-like material from chrome shavings. Sastry et al. (2005) highlighted that the preparation of regenerated leather consumer products from chrome shavings requires a careful choice of plant fibers and resins. Moreover, Senthil et al. (2014) reported that the preparation of regenerated leather from finished leather waste and plant fibers is economical, helps in reducing environmental pollution, and enhances its mechanical properties.

Thus, instead of focusing on particle board production which needs 80 % additional sawdust and additional fiber material and resins, it is highly advisable and recommended to focus on the Fabrication of Regenerated Leather Using Chrome Shavings for the production of regenerated leather consumer products from chrome shavings waste like key holders, light handbags, and wallets. There is also a huge market in Ethiopia for products like key holders, light handbags, and wallets.

The required machine for the production of regenerated leather consumer products from chrome shavings waste is a hot-pressing machine, a different kind of mold, plant fiber, and resins. It has to be noted the manual hot-pressing machine can be manufactured

locally. Besides the energy source for the electric heater can be electric power from the grid of solar energy using photovoltaic can be used as the temperature of the process is around 100 ^{O}C. Besides a pressure of 12 MPa required for the process can easily be generated using manual operation. Thus, there is a huge benefit in producing regenerated leather from chrome shaving instead of particle board: small-scale machines can be produced with local manufacturers, the products are well demanded in the market, and easy to produce, considering the process the start-up investment is small, etc.

6. Conclusions

The result of the assessment shows that of the six proposed projects by LLPI-RDC, three are feasible considering all the seven criteria outlined in the assessment criteria above. These projects are: Utilization of de-dust salt from raw hide/skin during the pickling process, Preparation of application of protein hydrolysate from chrome-bearing solid bi-products from tanneries, and Production of glue from hide limed trimmings. The summary of the financial cost-benefit of these projects is outlined below.

	Feasible Projects		
Criteria	**Glue Production**	**Protein Hydrolysate**	**Salt Recovery**
Investment Cost (ETB)	3,374,452	4,311,598	1,109,477
NPV (ETB)	25,623,430	81,902,364	5,402,941
IRR (%)	>150	>200	>120
Payback Period	<1yr	<1yr	<1yr
Job Creation Potential	25+	20+	20+

Collectively, these projects could enable an overall disposable waste reduction of 957 tons per year. Moreover, the projects would also enable foreign currency saving from reduced import of the final products, reduce disposal cost of toxic waste and also generate income tax for the government too. They would also improve public health (through reduced level of exposure to pathogens and toxic substances). In addition to the aforementioned benefits, it has also been evident that the projects can bring positive

impacts in instilling improved waste disposal practices as well as, contribute to regulatory change/amendment for better law enforcement.

For the other three projects, however, i.e. Preparation of leather board from chrome shavings, preparation of organic compost from tannery fleshing waste and brick production from tannery effluent sludge and clay, the assessment with respect to the first three criteria; i.e. waste supply and availability, technical and logistics requirements were found to not be viable, considering the importance of these criteria in ensuring competitiveness of the businesses with reference to the nature of already operational businesses.

Considering the wholistic impact of valorization from leather wastes to the Modjo area, the municipality's role for the successful realization of the projects will be rudimental. Some of the expected support may include: provision of land, facilitation of access to finance through the micro-financing institutions present locally and capacity development support.

7. Project Implementation Plan

The following table outlines the project implementation plan considering the major activities such as: loan approval, machinery acquisition & installation, and training of work force.

Major Work Blocks for Implementation	**2022**				**2023**
	Sep	**Oct**	**Nov**	**Dec**	**Jan**
Pre Project-Implementation Phase and Loan Approvals					
Completion of Building and construction					
Machinery and Equipment Manufacturing					
Erecting, Installation & Testing of machinery and equipment					
Training and Recruitment					
Ra-materials & supplies preparation (supply agreements) and trial production					
Commercial production					

The roles and responsibilities of major actors or relevant stakeholders for the successful implementation of the projects

S. N	Name of Stakeholders	Roles and responsibilities
1	LLPIRDC/MoI	○ Technical support and capacity building for the tannery bi-product conversion businesses ○ Supporting the businesses to ensure quality of their products and in providing laboratory service ○ Supervise the tanning companies to improve their solid bi-product management ○ Support in identifying budget sources for the projects
2	ELIA	○ Technical support and capacity building for the tannery bi-product conversion businesses ○ Facilitate the binding modality/agreement between different parts and tannery factories
3	EPA	○ Law enforcement and monitor the solid waste management ○ Define and implement clear incentive packages for pollution control measures particularly waste valorization
4	Modjo town admin.	○ Establish MSMEs and provision of capacity building ○ Land acquisition and creating market linkage ○ Facilitate smooth logistics activities and formulation of bindings frameworks
5	Tannery factories	○ Ensure proper segregation of tannery solid wastes/bi-products ○ Cooperate with bi-product conversion businesses and relevant stakeholders with regard to raw material supply. ○ Engage in some of the proposed projects or intervention measures
6	Development agencies	○ Technical support and capacity building for the tannery bi-product conversion businesses ○ Support in identifying budget sources for the projects
7	Manufacturing Technology & Engineering Industry Research & Development Center (MTEIRDC)	○ Support in designing and fabricating the machineries

8. Recommendations

- For the success of the project objectives through implementing the viable projects, there is a need for unreserved and a well-coordinated engagement & facilitating role by all stakeholders *(Modjo City Administration, Leather Processing Factories,*

SOLIDARIDAD, PIN, IRC, LLPI-RDC*, Financial Institutions, Regulatory Institutions, etc)*

- For the relatively non-viable businesses, considering the other best possible alternatives can ensure feasible results. *For example:*
    - Option can be explored for *Sludge & Fleshing Waste with multiple outcomes (energy, heat & fertilizer)*
    - Hide and Skin fleshing as a poultry feed
    - Production of regenerated leather can further be explored for *Chrome shaving waste enabling* a direct utilization of the waste with minimal complementary raw material need.
- Technical study has to be conducted for alternative bi-product valorization/conversion intervention measures in places of less viable projects.
- In general, there must be the binding modality between different stakeholders during the implementation of these projects
- Attention should be given to convert other sources of tannery solid bi-products/wastes such as finished trimmings into valuable products
- The conversion of tannery solid bi-products into valuable products is not only for their financial viability but also for their environmental and socio-economic benefits. Hence, any kind of subsides need to be arranged if possible
- Tannery factories, private companies(investors), TVET colleges etc can engage in the conversion of the tannery bi-products under intensive facilitation/support even though this feasibility is conducted for MSMEs. For instance, salt recovery project can be implemented by tannery industries

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10. Appendix

1. Key visual observations

A. Batu Tannery

Figure 38 : Tannery Waste Pictures from Batu Tannery visit

B. Ethiopia Tannery Modjo

Figure 39 :Pictures from Ethiopian Tannery visit, Modjo

C. Colba Tannery, Modjo

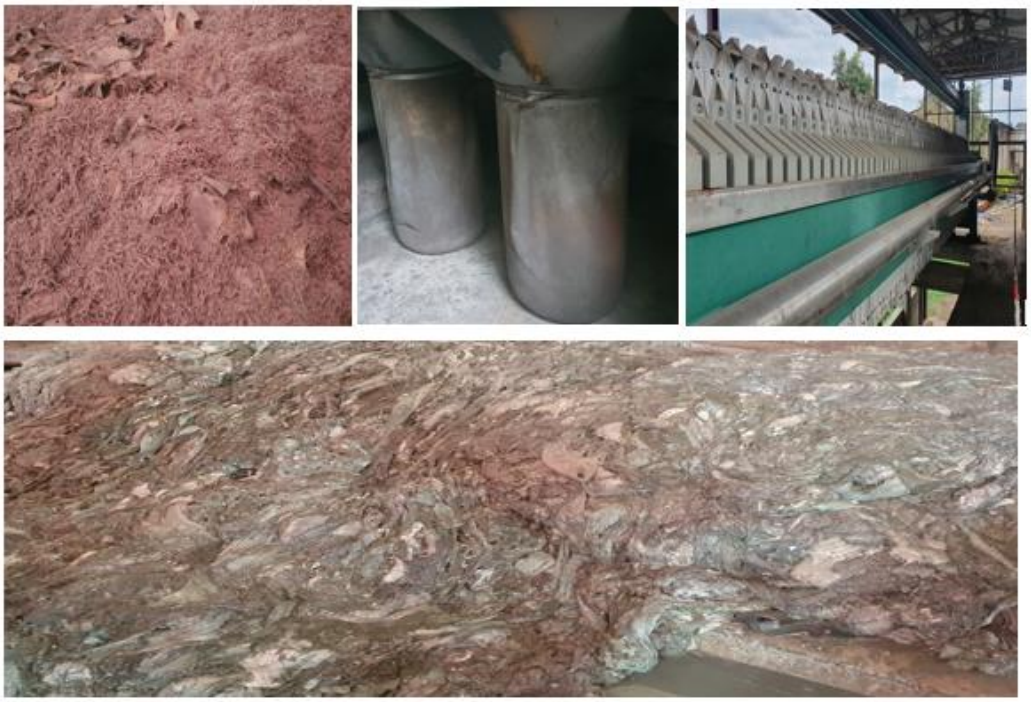

Figure 40: Pictures from Colba Tannery visit, Modjo

D. George Shoe Tannery, Modjo

Figure 41 : Pictures from George Shoe Tannery visit, Modjo

E. Small scale Enterprise of Glue production around Modjo area

Figure 42: Pictures from Small-scale Enterprise of Glue production around Modjo area

2. Mass and Energy balance for glue production systems

A. Mass Balance of the washing unit

The mass balance of the washing unit is depicted in table 1 and figure 1. The amount of water required to wash a daily hide capacity of 2500 kg/day is three times the weight of the hide i.e. 7571.25 liters. Besides the hide, contain dirt, salt, and sulfide. From the 2500 kg of hide, the amount of dirt, salt and sulfide is 23.75 kg.

Table 47 : Mass Balance of the washer

Item	Value	Unit
Glue Production Rate per day	500.00	kg/day
Conversion factor (Input to Glue)	0.20	-
Amount of Trimmed hide needed for glue production	2500.00	kg/day
Waste contains around 0.95 % dirt, salt and sulfide	0.0095	
The amount of dirt, salt, and sulfide	23.75	kg/day
The total amount of waste used for glue production	2476.25	kg/day
For 1kg of pelt 3 liters of Water is required	3.00	liter
Amount of water required	7428.75	liter
Density of water	1	kg/m^3
The mass of wastewater removed	7428.75	kg/day

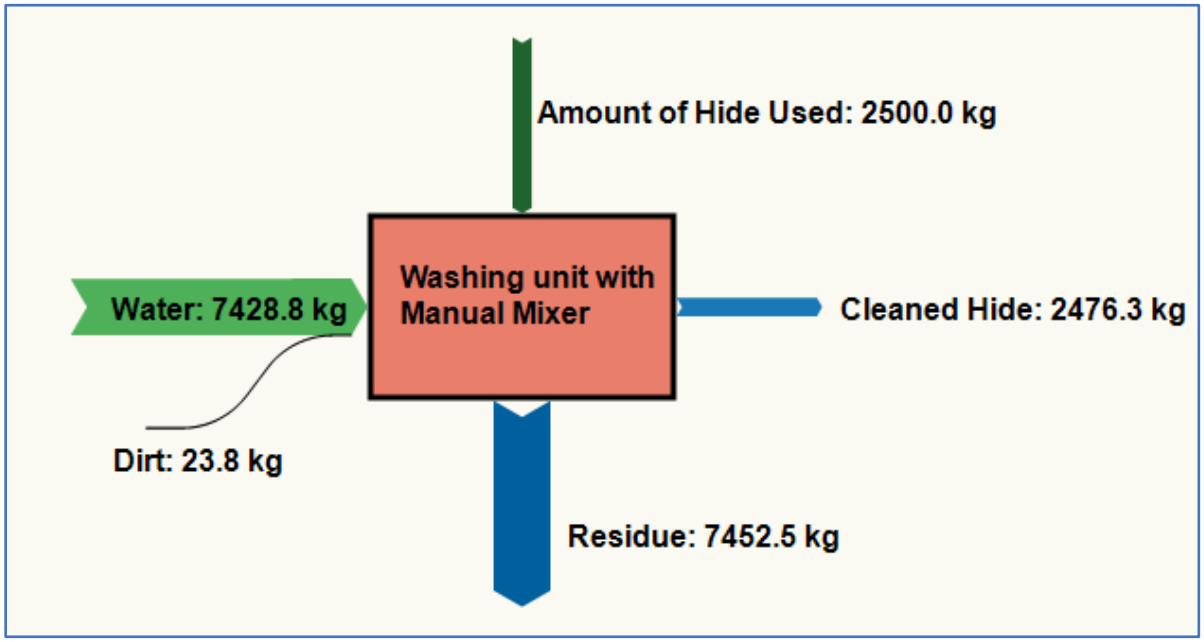

Figure 43: Mass Balance of the washer

B. Mass balance of soaking unit

The mass balance of the soaking unit is depicted in table 2 and figure 2. The amount of hide after washing is 2500 kg/day is two times the weight of the hide i.e. 4952.5 liters. The mass of the hide increases by 150% due to soaking. 10 % of lime is also deposited on the hide. Thus, the total amount of hide will be 3853.045 kg/day after soaking.

Table 48: Material balance on soaking unit

Item	Value	Unit
Mass of the hide after washing	2476.25	kg/day
Mass water required (for 1 kg of hide 2 liter of water required)	4952.5	kg/day
Mass of the hide increase by 150%	2847.6875	kg/day
Mass of lime removed (10 %)	495.25	kg/day
Mass of Hide after soaking	3853.045	kg/day

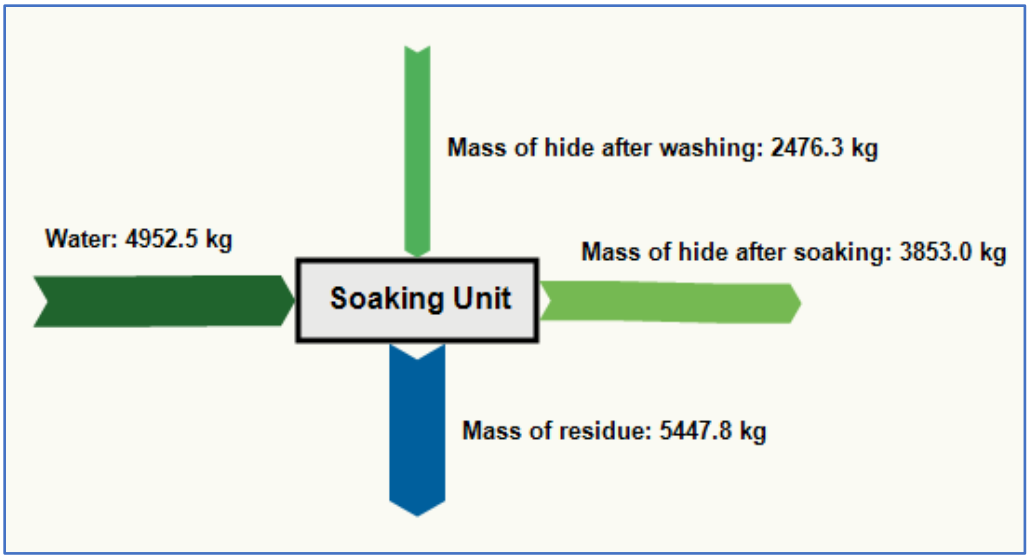

Figure 44: Material balance on soaking unit

C. Mass balance of the Neutralization unit

The mass balance of the soaking unit is depicted in table 2 and figure 2. The amount hide after washing is 3853.045 kg/day. The amount of water required is two times the weight of the hide i.e. 7706.09 liters. 65 liter is of acid solution with 5 % concertation is required.

Table 49 : Mass of the Neutralization unit

Item	Value	Unit
Mass of Hide after soaking	3853.045	kg/day
Mass of water required for neutralization process (2 liters for 1 kg of hide)	7706.09	kg/day
Amount of HCL required (7 ml for 1 kg of hide with 5 % concentration)	65.501765	liter
Amount of HCL required (7 ml for 1 kg of hide with 5 % concentration)	0.07	m^3
Density of 5% HCl at 20^oC	1023.00	kg/m^3
Mass of 5% HCl	67.01	kg/day
Mass of the hide after neutralization	3714.375	kg/day
Amount of wastewater removed	7773.10	kg/day

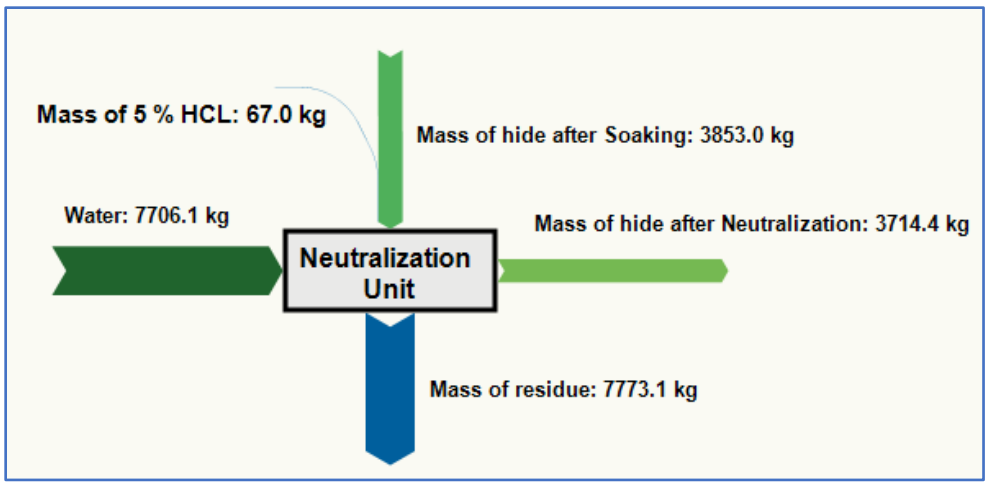

Figure 45: Mass of the Neutralization unit

D. Mass balance of the extraction unit

The mass balance of the soaking unit is depicted in figure 4. The amount hide after neutralization is 3714.38 kg/day. The amount of water required was 7428.75 liter. The mass of glue produced us 742.875 kg/day.

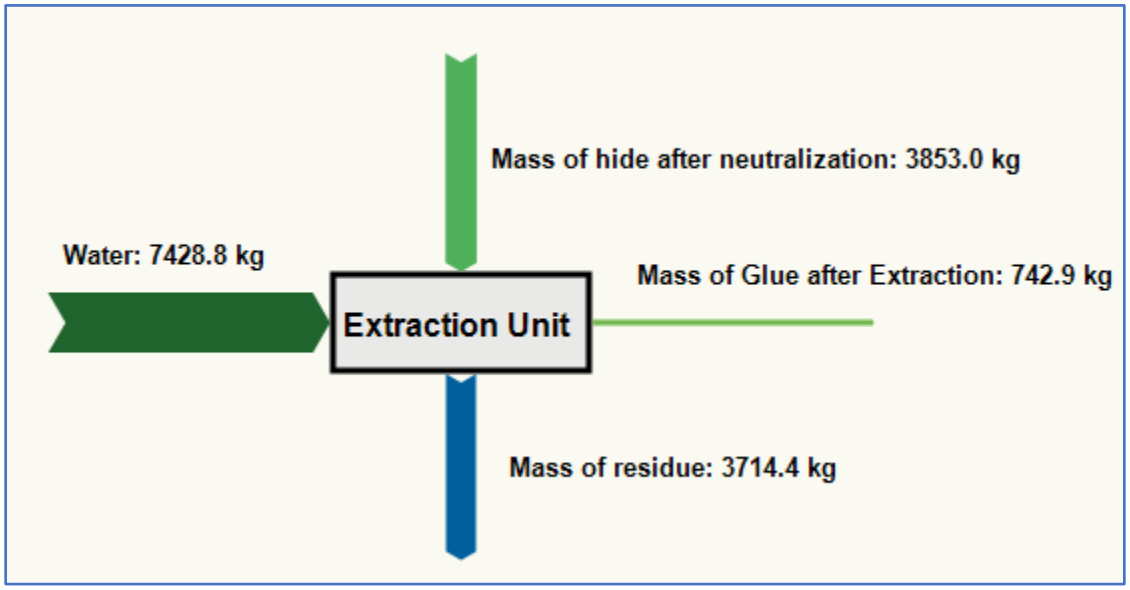

Figure 46 : Mass balance of the extraction unit

E. Energy Balance

The energy balance of the 1st extraction unit is shown in table 4.

Table 50 : Energy balance of the 1st extraction unit

Item	Value	Unit	
Initial Temperature	25	^{O}C	
Target Temperature	80		
Temperature of steam	121		
Heat capacity of the feed	2.9	kJ/kgk	
Extraction time	4	hr	
Overall heat transfer coefficient	200	kJ/hm^3k	
Heat of vaporization			
Enthalpy of condensate	580.46	kJ/kg	121 ^{O}C
Enthalpy of saturated vapor	2707.9	kJ/kg	121 ^{O}C
Mass flow rate of steam in kg/day			
Mass of feed (Mass of hide after neutralization + Mass of water)	11143.125	kg/day	
Mass of feed (Mass of hide after neutralization + Mass of water)	464.29688	kg/h	
Area of Heat Exchanger for 1st Extraction	1.43	m^2	
Heat of Vaporization	2127.44	kJ/kg	
Mass of Steam required to heat the hide at 70 ^{O}C	5.52	kg/h	

F. Sizing of the system

G. Sizing of the washing machine

Table 51 : Sizing of washing machine

Item Value Unit		
Mass of hide	2500.00	kg/day
Mass of water	7500	kg/day
Density of hide	980	kg/m^3
Volume of water_V_w	7.5	m^3/day
Volume of hide_V_h	2.55	m^3/day
Total Volume (V_T) = V_h + V_W	10.05	m^3/day
Total Volume (V_T) = V_h + V_W	0.53	m^3/hr
Actual volume required	0.6	m^3

H. Sizing of the soaking machine

Table 52 : Sizing of soaking machine

Items	Value	Unit
Mass of the hide after washing	2476.25	kg/day
Mass water required (for 1 kg of hide 2 liter of water required)	4952.5	kg/day
Mass of lime	495.25	kg/day
Density of lime	963.87	kg/m^3
Volume of hide_V_h	2.53	m^3/day
Total Volume (V_T) = V_h + V_W	4.95	m^3/day
Volume of lime (V_L)	0.51	m^3/day
Total Volume (V_T) = V_h + V_W + V_L	971.35	m^3/day
Total Volume (V_T) = V_h + V_W + V_L	7.99	m^3/hr
Actual volume required	9.4	m^3

I. Sizing of the Neutralization machine

Table 53 : Sizing of the Neutralization machine

Items Value Unit		
Mass of Hide after soaking	3853.05	kg/day
Mass of water required for neutralization process (2 liter for 1 kg of hide)	7706.09	kg/day
Volume of HCL required (7 ml for 1 kg of hide with 5 % concentration)_V_a	0.07	kg/m^3
Volume of hide_V_h	3.93	m^3/day
Volume (V_T) of water	7.71	m^3/day
Total Volume (V_T) = Va + V_h + Vw	11.70	m^3/day
Total Volume (V_T) = Va + V_h + Vw	0.49	m^3/hr
Actual volume required	0.6	m^3

J. Sizing of the Extraction unit

Table 54 : Sizing of the Extraction unit

Sizing of 1st Extraction Unit		
Mass of hide after neutralization	3714.38	kg/day
Mass of water required for extraction process (2 liter for 1 kg of hide)	7428.75	kg/day
Volume of hide_V_h	3.79	m^3/day
Volume (Vw) of water	7.43	m^3/day
Total Volume (V_T) = V_h + Vw	11.22	m^3/day
Total Volume (V_T) = V_h + Vw	0.78	m^3/hr
Actual volume required	3.7	m^3

3. Questionnaires and Interview Questions

Questions/ Assessment Areas Identified for the Evaluation Criteria

Criteria 1: Waste supply and Availability

1. What is the practices of current waste management practices at the tannery companies-collection, segregation, labelling, storage, treatment/disposal etc
2. Quantity of waste generated (kg/day)
3. Maximum quantity of waste to be collected (Kg/day)
4. What is the nature/characteristics of the waste generated from the specific processes?
5. What is the quality of waste that are currently collected? Is the waste appropriate for the intended purpose?

Reliability of resource supply

6. Is the waste found all over the tannery industries and available every month?
7. Are there a variation of waste quality and quantity over seasons?
8. Are there supply limitations of the resource input? Will there be adequate supply of the correct type of waste, in a usable form (or a form that can be relatively easily and inexpensively separated), in a suitable location
9. What is the stability of the waste over time during transportation or storage?

10. How easily the waste is collected and transported? Is there any issue related with construction of materials for transporting?

Competitors' index for waste resource

11. What is the current use of the waste i.e., which potentially competing alternative destinations exist?
12. What is the performance of waste conversion if similar business intervention exists?
13. How companies want to transfer/deliver wastes? What is the cost of waste? Do you think the company gives the hide-limed trimmings for free?

Criteria 2: Institutions, Regulations and investment climate

Structure and capacity of institutions

1. What organizations and boundary partners involved the waste valorization interventions and what are their responsibilities and interlinkages?
2. What are the processes and instruments for implementation, monitoring and enforcement?

Policy and legal Framework support

3. Is the waste supply legal and who are the actors along the waste management service value chain?
4. What policy and regulatory legal documents exist in support of or in opposition to waste valorization interventions? Under what conditions wastes from industry are reused or recycled?
5. Is legislation enforced? If no why?
6. What supportive legal incentives are there for existing and future waste valorization interventions?
7. Are there any stakeholders that will make the implementation of waste valorization initiatives easy or difficult and how influential are they?
8. How easy is land access?

Level of budgetary and other issues

9. What is the level of budgetary or fiscal support for waste valorization initiatives, if any?
10. Are there investors, banks or donors in the town/region who are interested in (co)funding waste valorization businesses?
11. What budgetary allocation is made for business in the region?
12. How are these allocations (e.g., via grants, loans, subsidies?
13. What is the process by which funding can be obtained for the business and is it a complicated process?

Community support

14. What are communities' awareness on laws around waste management and associated projects?
15. Are communities aware of the waste valorization objectives?
16. What is the degree of public (community) acceptance of the proposed waste valorization intervention(s)?
17. What kind of waste valorization options communities know, how do they perceive/support/reject them, and can we explore communities' perceptions about other waste valorization options?

Status of investment climate for waste conversion operations

18. What is the status of the capital market as related to the willingness of financial institutions to invest in waste valorization initiatives, probable terms of financing available from banks and other investors, and the nature of financing mechanisms?
19. What are the local determinants of a supportive investment climate and implications for new business set up and development in the waste management sector? including bottlenecks that have been experienced?

Criteria 3: Market Assessment

1. Who is the targeted customer segments?

Information on customer segments will include:

- Category of customer segments as (business-consumer) and/or (business-business).
- Pains (undesired outcomes in doing jobs, obstacles and risk of failure).
- Gains (Required, expected, desired and unexpected).
- Priorities (customer's priority of listing for the jobs, pains, gains).
- Requirements to buy your product (design, function, price,).
- Motivation and fear factors.
- What makes them special and identifiable.
- Others relevant information to their decision to buy your product/service.

2. What is the target market?

- A full description of the target market (or launching market) will be made including, main players & their market shares, existing products & services, selling prices, competition structures, market size, market growth, weaknesses, strengths and key issues for further consideration.

3. What is the unique value proposition?
4. What is the evidence for product-market fit?

- How the product's offering (incl. specifications, value propositions, commercial offering, channel distribution) will be fit for the target market and requirements of the customer segments.

5. What is the competitive positioning?
6. What are the distribution channels selected and why?
7. How to develop, retain and grow customers?

- How to launch the product, get the new customers, retain and grow them. What are the key assumptions and strategies on how to achieve all of the customer relation deliverables? What are the key strategies to develop customers are increasing awareness, loyalty and growing customers? What are the tactics for each customer development strategy and metrics for control?

Criteria 4: Technical and logistical assessment

Generic issues

1. Description of production flow diagram. Indicate mass balance of the systems/measures.
2. Type of machines/equipment to be used
3. What is the type, sources and quantity of inputs used (water, chemical, energy) during the waste valorization processes of each intervention measures? Indicate the prices of each input.
4. Explain the number of days required to produce one batch of product from the waste
5. Describe comparative advantages of product e.g glue produce from hide limed trimmings compared to imported glue.
6. Where do you think the idea position for the production of valuable products from wastes? Inside the company or our side, the leather industry?
7. Do you know nay private companies or initiatives who is generating glue from hide limed trimmings in Ethiopia?
8. What do you think will be the main changes to start this kind of business?

Availability of technologies

9. What suitable technologies are available locally for the proposed waste valorization intervention?
10. Does the technology have a positive record of accomplishment in the country and who was operating it?

Technology (resource) requirements index (spare parts, other production factors)

11. Which technical options are available for the calculated production scenarios?
12. Are there resource constraints related to labor, land, energy or other factors of production?

Performance and efficiency of technology

13. What is the level of performance and efficiency of the proposed technology?

14. What is the percentage of resource output recovered from the process (input-output ratio)?
15. What are optimum conditions for each waste valorization
16. How robust is the technology?
17. What is the degree of technical complexity as related to the equipment, infrastructure, O&M and locally available technical expertise?
18. What are the major limitations associated with the production process?

Operation and maintenance (O&M) requirements

19. Are there local institutional and human capacity to operate and maintain any suggested technology, related processes and production cycle

Criteria 5: Financial Analysis

1. What is the revenue streams and plan for selling?

- How to sell the product (transactional or recurring), what is the pricing type of the product (license fees, leasing, product price,..etc), offered credit facilities, cash flow projections, selling plan, marketing plan & budget, sales projections and others

2. What is the cost structure?

- The production cost (in terms of variables or fixed costs) to produce the set products. The operating and capital costs and funding options. Projections of costs and funds. The cost of a product produced (ETB/ product), projection of production cost, classification of costs (variables and fixed), evaluate funding options, recommendation of funding option and justifications.

3. What is the investment cost of the project and how to fund it?

- What is the investment cost of the project, including working capital and fixed assets, ways for funding, recommendation of funding and justifications?

4. What is the financial projections?

- What are the assumptions of the financial projection and figures for minimum 10 years term (income statement, balance sheet and cash flow statements). The

reliability and consistency of projections will be the basis for judging and acceptance.

5. What is the evidence of viability?

- Financial viability tests will be carried out including, calculating the net present value NPV, internal rate of return IRR, payback period, financial ratio analysis and others. The reliability and consistency of viability will be the basis for judging and acceptance.

Criteria 6: Health and Environmental Risk and Impact Assessment **Work-related risks (types, frequency and severity of potential accidents) at the waste converting unit**

1. What are the known occupational health hazards associated with the implementation of the waste valorization intervention (from waste acquisition to transformation)? Indicate the types of occupational hazards.
2. What are the potential critical exposure points along the value chain of the intervention under consideration?
3. What are the potential risks to the different exposure groups (e.g., workers, consumers)?
4. What are the potential health impacts (positive and negative) at the specific system boundary level?

Health risk reduction strategies in place (e.g., safety equipment, training) for the waste to resource process

5. What are the relevant national standards to be observed and complied with for the proposed waste valorization (WV) intervention?
6. What (additional) risk mitigation processes/measures can be put in place along the value chain?
7. What institutional arrangements exist for health risk assessment, mitigation and monitoring, and how effective are they?
8. What is the most cost-effective combination of control measures to guarantee a safe end-product?

9. What operational and verification monitoring is needed (parameter and critical limit) as well an incentive system for compliance to ensure that the controls are working as required?
10. Are there practicable strategies available for adherence of end-product to public health standards?
11. What are the likely health benefits from implementation of the proposed WV intervention?

Estimated emissions (solids fluids and gas) to waterbodies soil and air

12. What are the resources used for the operation of waste valorization processes?
13. What are the types of wastes generated from the operation of the intervention measures? Hazardous or non-hazardous, solid/liquid/gas emission
14. List down the significant environmental aspects related with the operation of waste valorization projects starting from raw material acquisition to final product. The environmental aspects may be associated with use of raw materials, chemicals, water, energy during waste supply, production, packaging, transportation and use of final products
15. What are the environmental impacts of each environmental aspects? Estimate the quantity and load of the emission from each processes/aspect.
16. What mitigation measures are applicable/available to avoid or reduce the environmental impacts? Are the mitigation measures affordable?
17. Who will support the mitigation measures?
18. What are the potential positive and negative Environmental impacts of the proposed waste valorization intervention and use of recovered resources in the long run?

Criteria 7: Socio-economic Impact Assessment

Socio-economic benefit indicators

1. Estimated number of direct and indirect jobs created
2. Incremental gain in crop yields e.g use of compost

3. Foreign currency saved from reduced import of substitute products (e.g., fertilizer, energy and raw material etc.)
4. Decrease in extracting/utilizing original raw materials
5. Cost savings (transport, labor) from avoided waste disposal

Socio-economic cost indicators

6. Estimated increase in energy demand from waste transformation
7. Increase in on-farm labor requirements through compost use

Environmental and health benefit indicators

8. Improved legal compliance or waste management due to the implementation of waste valorization processes
9. Cost savings from estimated averted atmospheric GHG emissions
10. Cost savings from averted human exposure to untreated waste (reduced level of exposure to pathogens and toxic substances)

Environmental and health be cost indicators

11. Costs of estimated atmospheric GHG emissions from the resource recovery process
12. Estimated emissions (solids and fluids) to waterbodies and soil
13. Level of exposure to pathogens and toxic substances from inputs, outputs and by-products of the process

II. Interview questions for selected Tannery Industries

Name of factory: _____

Questions/checklists

1. Annual production capacity (installed and attainable) per year
    - Hide
    - Skin
2. Number of working days per year

3. Waste management practices (collection/segregation, storage, transport and disposal)
    - Treatment/disposal (methods, cost, site, legal issue etc)
4. Quantity of waste generated (kg/day), kg/year

S.N	Type of waste	Quantity	Disposal methods	Frequency & Cost of disposal	Cost of waste if sold (ETB/kg)
1	Limed trimming				
2	Limed splits				
3	De-dusted salt				
4	Fleshing				
5	Chrome bearing waste				
6	Chrome shaving				
7	Tanned trimmings				
8	Buffing waste				
9	Biological sludge				

5. Reliability of supply of waste over time
6. Tendency to transfer waste free of charge
7. Willingness of the tanneries to use recovered materials (salt, protein hydrolysate, chrome)
8. Cost of salt (ETB/Kg) including transport cost
9. Cost of protein filler and chrome
10. Challenges and opportunities with waste management

III. Interview questions for Modjo Town Administration

1. What organizations and boundary partners involved in the waste valorization interventions and what are their responsibilities and interlinkages?
2. Support from Modjo Municipality for waste conversion projects (legal/policy frame work, incentives, capacity building etc
3. Level of budgetary (sources, mechanism, process)
4. Community support on waste conversion projects (awareness, public acceptance, perception)

5. Availability of land /rental house for waste conversion businesses & corresponding costs
6. Wage rate for workers at Modjo town
7. Estimation of transportation cost around Modjo
8. Existing waste conversion businesses around modjo town (compost, bricks, particle board, others, None
9. Waste disposal facility (Type, cost, requirements)
10. Compliance or legal requirements related tannery solid waste management
11. Date on traditional glue producers
    - Year of establishment
    - Their number and production capacity
    - Raw material source, cost (ETB/kg), consumption (Kg/day)
    - Marketing and price of product, challenges from the market
12. Any other challenges and opportunities related with waste management

4. Summary of Financial Analysis

Protein Hydrolysate Project

Description	Proejct Years										
	0	1	2	3	4	5	6	7	8	9	10
Cash Inflows											
Owner's Equity	(1,282,088)										
Bank Loan	(2,991,538)										
Net Profit		20,614,643	22,208,091	16,658,133	17,768,545	18,880,047	18,904,085	18,928,122	18,952,159	18,976,194	19,000,229
Depreciation & Amort		379,906	379,906	379,906	379,906	379,906	379,906	379,906	379,906	379,906	379,906
Total Cash Inflows		**20,994,549**	**22,587,997**	**17,038,039**	**18,148,451**	**19,259,953**	**19,283,991**	**19,308,028**	**19,332,065**	**19,356,100**	**19,380,135**
Cash out Flows											
Fixed assets	3,212,811										
Working capital		977,018	1,041,214	1,106,623	1,178,409	1,238,688	1,238,690	1,238,693	1,238,695	1,238,698	1,238,700
Increase In workng Capital											
Pre-Operating Costs	83,797										
Pre-Operating Interest	-										
Loan Repayment		643,181	823,971	789,568	755,165	720,762	686,360	651,957	617,554	583,152	548,749
Dividened/Withdrawal		4,122,929	4,441,618	3,331,627	3,553,709	3,776,009	3,780,817	3,785,624	3,790,432	3,795,239	3,800,046
Replacment						-					
Total Cash Outflows	**3,296,607**	**5,743,127**	**6,306,803**	**5,227,818**	**5,487,283**	**5,735,460**	**5,705,867**	**5,676,274**	**5,646,681**	**5,617,088**	**5,587,495**
Net Cash Flow	(3,296,607)	15,251,422	16,281,195	11,810,222	12,661,168	13,524,493	13,578,124	13,631,754	13,685,383	13,739,012	13,792,640
Cumulative Cash Balance		**15,251,422**	**22,587,997**	**17,038,039**	**18,148,451**	**19,259,953**	**19,283,991**	**19,308,028**	**19,332,065**	**19,356,100**	**19,380,135**

DESCRIPTION	YEARS										
	0	1	2	3	4	5	6	7	8	9	10
ASSETS											
CURRENT ASSETS											
Cash		15,251,422	22,587,997	17,038,039	18,148,451	19,259,953	19,283,991	19,308,028	19,332,065	19,356,100	19,380,135
Inventory	977,018	977,018	1,041,214	1,106,623	1,178,409	1,238,688	1,238,690	1,238,693	1,238,695	1,238,698	1,238,700
Total Current Assets	**977,018**	**16,228,440**	**23,629,211**	**18,144,662**	**19,326,860**	**20,498,640**	**20,522,681**	**20,546,721**	**20,570,760**	**20,594,798**	**20,618,835**
FIXED ASSETS											
Main Machineries	1,131,811	1,018,630	905,449	792,268	679,087	565,905	452,724	339,543	226,362	113,181	(0)
Auxilary Equipment	75,000	67,500	60,000	52,500	45,000	37,500	30,000	22,500	15,000	7,500	-
Office equipment & furniture	142,500	128,250	114,000	99,750	85,500	71,250	57,000	42,750	28,500	14,250	-
Vehicle	1,012,000	809,600	607,200	404,800	202,400	-	-	-	-	-	-
Total Fixed Assets	**1,349,311**	**1,214,380**	**1,079,449**	**944,518**	**809,587**	**674,655**	**539,724**	**404,793**	**269,862**	**134,931**	**(0)**
Sub Total											
Pre-operating costs	851,500	808,925	766,350	723,775	681,200	638,625	596,050	553,475	510,900	468,325	425,750
Pre-operating interest	-	-	379,906	-	-	-	-	-	-	-	-
Sub-total	**851,500**	**808,925**	**1,146,256**	**723,775**	**681,200**	**638,625**	**596,050**	**553,475**	**510,900**	**468,325**	**425,750**
Total Assets	**3,177,829**	**18,251,745**	**25,854,916**	**19,812,955**	**20,817,646**	**21,811,921**	**21,658,455**	**21,504,989**	**21,351,522**	**21,198,054**	**21,044,585**
LIABILITIES & Capital											
Outstanding Loan	2,991,538	2,348,357	1,524,387	734,819	(20,346)	(741,109)	(1,427,469)	(2,079,426)	(2,696,980)	(3,280,132)	(3,828,881)
Sub Total	**2,991,538**	**2,348,357**	**1,524,387**	**734,819**	**(20,346)**	**(741,109)**	**(1,427,469)**	**(2,079,426)**	**(2,696,980)**	**(3,280,132)**	**(3,828,881)**
CAPITAL											
Owner's Equity*	1,282,088	1,282,088	1,282,088	1,282,088	1,282,088	1,282,088	1,282,088	1,282,088	1,282,088	1,282,088	1,282,088
Retained Earnings		16,491,714	34,258,187	47,584,694	61,799,530	76,903,567	92,026,835	107,169,333	122,331,060	137,512,015	152,712,198
Sub total	**1,282,088**	**17,773,802**	**35,540,275**	**48,866,782**	**63,081,618**	**78,185,655**	**93,308,923**	**108,451,420**	**123,613,147**	**138,794,103**	**153,994,286**
Total Liabilities and Capital	**4,273,625**	**20,122,159**	**37,064,662**	**49,601,600**	**63,061,271**	**77,444,546**	**91,881,454**	**106,371,995**	**120,916,167**	**135,513,971**	**150,165,405**

De-dusted Salt Project

Description	Proejct Years										
	0	1	2	3	4	5	6	7	8	9	10
Cash Inflows											
Owner's Equity	(332,843)										
Bank Loan	(776,634)										
Net Profit		1,922,774	2,092,808	1,897,645	2,035,137	2,173,792	2,181,248	2,188,703	2,196,157	2,203,609	2,211,061
Depreciation & Amort		67,730	67,730	67,730	67,730	67,730	67,730	67,730	67,730	67,730	67,730
Total Cash Inflows		**1,990,504**	**2,160,538**	**1,965,375**	**2,102,867**	**2,241,522**	**2,248,978**	**2,256,433**	**2,263,887**	**2,271,339**	**2,278,791**
Cash out Flows											
Fixed assets	910,300										
Working capital	177,423										
Increase In workng Capital											
Pre-Operating Costs	21,754										
Pre-Operating Interest	-										
Loan Repayment		166,976	594,728	585,797	576,865	567,934	559,003	550,072	541,140	532,209	523,278
Dividened/Withdrawal				379,529	407,027	652,138	1,090,624	1,094,351	1,098,078	1,101,805	1,105,531
Replacment						-					
Total Cash Outflows	**1,109,477**	**166,976**	**594,728**	**965,326**	**983,893**	**1,220,072**	**1,649,627**	**1,644,423**	**1,639,219**	**1,634,014**	**1,628,808**
Net Cash Flow	(1,109,477)	1,823,528	1,565,810	1,000,050	1,118,975	1,021,450	599,351	612,010	624,668	637,326	649,983
Cumulative Cash Balance		**1,823,528**	**3,389,338**	**4,389,387**	**5,508,362**	**6,529,812**	**7,129,163**	**7,741,173**	**8,365,841**	**9,003,167**	**9,653,150**
Debt Service Coverage		10.92	2.63	2.36	2.65	2.95	3.02	3.10	3.18	3.27	3.35

DESCRIPTION	YEARS										
	0	1	2	3	4	5	6	7	8	9	10
ASSETS											
CURRENT ASSETS											
Cash		1,823,528	3,389,338	4,389,387	5,508,362	6,529,812	7,129,163	7,741,173	8,365,841	9,003,167	9,653,150
Inventory	177,423	177,423	187,371	198,398	210,583	221,559	221,561	221,564	221,566	221,568	221,570
Total Current Assets	**177,423**	**2,000,951**	**3,576,709**	**4,587,785**	**5,718,945**	**6,751,372**	**7,350,725**	**7,962,737**	**8,587,407**	**9,224,735**	**9,874,720**
FIXED ASSETS											
Main Machineries	235,800	212,220	188,640	165,060	141,480	117,900	94,320	70,740	47,160	23,580	-
Auxilary Equipment	80,000	72,000	64,000	56,000	48,000	40,000	32,000	24,000	16,000	8,000	-
Office equipment & furniture	92,500	83,250	74,000	64,750	55,500	46,250	37,000	27,750	18,500	9,250	-
Vehicle	12,000	9,600	7,200	4,800	2,400	-	-	-	-	-	-
Total Fixed Assets	**408,300**	**367,470**	**326,640**	**285,810**	**244,980**	**204,150**	**163,320**	**122,490**	**81,660**	**40,830**	**-**
Sub Total											
Pre-operating costs	490,000	465,500	441,000	416,500	392,000	367,500	343,000	318,500	294,000	269,500	245,000
Pre-operating interest	-	-	67,730	-	-	-	-	-	-	-	-
Sub-total	**490,000**	**465,500**	**508,730**	**416,500**	**392,000**	**367,500**	**343,000**	**318,500**	**294,000**	**269,500**	**245,000**
Total Assets	**1,075,723**	**2,833,921**	**4,412,079**	**5,290,095**	**6,355,925**	**7,323,022**	**7,857,045**	**8,403,727**	**8,963,067**	**9,535,065**	**10,119,720**
LIABILITIES & Capital											
Outstanding Loan	776,634	609,658	14,930	(570,867)	(1,147,732)	(1,715,667)	(2,274,669)	(2,824,741)	(3,365,881)	(3,898,090)	(4,421,368)
Sub Total	**776,634**	**609,658**	**14,930**	**(570,867)**	**(1,147,732)**	**(1,715,667)**	**(2,274,669)**	**(2,824,741)**	**(3,365,881)**	**(3,898,090)**	**(4,421,368)**
CAPITAL											
Owner's Equity*	332,843	332,843	332,843	332,843	332,843	332,843	332,843	332,843	332,843	332,843	332,843
Retained Earnings		1,922,774	4,015,582	5,533,698	7,161,808	8,683,463	9,774,087	10,868,438	11,966,516	13,068,321	14,173,852
Sub total	**332,843**	**2,255,618**	**4,348,425**	**5,866,541**	**7,494,651**	**9,016,306**	**10,106,930**	**11,201,281**	**12,299,359**	**13,401,164**	**14,506,695**
Total Liabilities and Capital	**1,109,477**	**2,865,275**	**4,363,355**	**5,295,674**	**6,346,919**	**7,300,639**	**7,832,260**	**8,376,540**	**8,933,478**	**9,503,074**	**10,085,327**

Glue Project

Projected Cash Flow											
Description	**Proejct Years**										
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Cash Inflows											
Owner's Equity	(1,012,335)										
Bank Loan	(2,362,116)										
Net Profit		5,920,023	8,305,202	6,246,432	6,679,222	7,112,013	7,131,028	7,150,043	7,169,058	7,188,073	7,207,088
Depreciation & Amort		316,939	316,939	316,939	316,939	316,939	316,939	316,939	316,939	316,939	316,939
Total Cash Inflows		**6,236,962**	**8,622,141**	**6,563,371**	**6,996,162**	**7,428,952**	**7,447,967**	**7,466,982**	**7,485,998**	**7,505,013**	**7,524,028**
Cash out Flows											
Fixed assets	2,670,644										
Working capital	637,642										
Increase In workng Capital											
Pre-Operating Costs	66,166										
Pre-Operating Interest	-										
Loan Repayment		507,855	758,825	731,661	704,497	677,332	650,168	623,004	595,839	568,675	541,511
Dividened/Withdrawal				1,249,286	1,335,844	2,133,604	3,565,514	3,575,022	3,584,529	3,594,037	3,603,544
Replacment						-					
Total Cash Outflows	**3,374,452**	**507,855**	**758,825**	**1,980,947**	**2,040,341**	**2,810,936**	**4,215,682**	**4,198,025**	**4,180,368**	**4,162,712**	**4,145,055**
Net Cash Flow	(3,374,452)	5,729,107	7,863,316	4,582,424	4,955,821	4,618,016	3,232,285	3,268,957	3,305,629	3,342,301	3,378,973
Cumulative Cash Balance		**5,729,107**	**13,592,423**	**18,174,846**	**23,130,667**	**27,748,683**	**30,980,968**	**34,249,926**	**37,555,555**	**40,897,856**	**44,276,828**

Projected Balance Sheet											
DESCRIPTION	**Y E A R S**										
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
ASSETS											
CURRENT ASSETS											
Cash		5,729,107	13,592,423	18,174,846	23,130,667	27,748,683	30,980,968	34,249,926	37,555,555	40,897,856	44,276,828
Inventory	637,642	637,642	560,957	596,917	647,426	670,158	670,158	670,158	670,158	670,158	670,158
Total Current Assets	**637,642**	**6,366,750**	**14,153,380**	**18,771,764**	**23,778,093**	**28,418,841**	**31,651,127**	**34,920,084**	**38,225,713**	**41,568,014**	**44,946,987**
FIXED ASSETS											
Main Machineries	420,309	378,278	336,247	294,216	252,185	210,154	168,123	126,093	84,062	42,031	-
Auxilary Equipment	93,335	84,002	74,668	65,335	56,001	46,668	37,334	28,001	18,667	9,334	-
Office equipment & furniture	118,500	106,650	94,800	82,950	71,100	59,250	47,400	35,550	23,700	11,850	-
Vehicle	1,012,000	809,600	607,200	404,800	202,400	-	-	-	-	-	-
Total Fixed Assets	**632,144**	**568,929**	**505,715**	**442,500**	**379,286**	**316,072**	**252,857**	**189,643**	**126,429**	**63,214**	**-**
Sub Total											
Pre-operating costs	1,026,500	975,175	923,850	872,525	821,200	769,875	718,550	667,225	615,900	564,575	513,250
Pre-operating interest	-	-	316,939	-	-	-	-	-	-	-	-
Sub-total	**1,026,500**	**975,175**	**1,240,789**	**872,525**	**821,200**	**769,875**	**718,550**	**667,225**	**615,900**	**564,575**	**513,250**
Total Assets	**2,296,286**	**7,910,854**	**15,899,884**	**20,086,789**	**24,978,579**	**29,504,788**	**32,622,534**	**35,776,952**	**38,968,042**	**42,195,803**	**45,460,237**
LIABILITIES & Capital											
Outstanding Loan	2,362,116	1,854,261	1,095,436	363,775	(340,722)	(1,018,054)	(1,668,222)	(2,291,226)	(2,887,066)	(3,455,741)	(3,997,251)
Sub Total	**2,362,116**	**1,854,261**	**1,095,436**	**363,775**	**(340,722)**	**(1,018,054)**	**(1,668,222)**	**(2,291,226)**	**(2,887,066)**	**(3,455,741)**	**(3,997,251)**
CAPITAL											
Owner's Equity*	1,012,335	1,012,335	1,012,335	1,012,335	1,012,335	1,012,335	1,012,335	1,012,335	1,012,335	1,012,335	1,012,335
Retained Earnings		5,920,023	14,225,224	19,222,370	24,565,748	29,544,157	33,109,671	36,684,692	40,269,222	43,863,258	47,466,802
Sub total	**1,012,335**	**6,932,358**	**15,237,560**	**20,234,705**	**25,578,083**	**30,556,492**	**34,122,006**	**37,697,028**	**41,281,557**	**44,875,594**	**48,479,138**
Total Liabilities and Capital	**3,374,452**	**8,786,619**	**16,332,996**	**20,598,480**	**25,237,361**	**29,538,438**	**32,453,784**	**35,405,802**	**38,394,492**	**41,419,853**	**44,481,886**

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