

## Quantification of Solid Waste Leather Generation Rate from the Ethiopian Leather Sector - A Contributing Perspective to Waste Management Approach

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### Abstract

Ethiopia is a country located in eastern Africa with huge livestock resource that could be a base for the tanning sector as it supplies ample raw material (hide and skin). The existence of raw material on the other hand implies good opportunity for the existence of tanning industry, foot wear and garment and goods manufacturing. As far as there are leather processing industries, waste generation also inevitably exists. The purpose of this study therefore is intended to quantify/estimate the solid leather waste generated from the industry and indicate the way forward of its disposal. Secondary data from Sheba Leather Industry, four year performance data from all tanneries, observational survey in three potential shoe factories and a two year data from pitards garment and goods manufacturing company was taken and analyzed to estimate the solid waste generation rate. Qualitative data collected from each company using questionnaire survey was also incorporated. The study results indicated that significant amounts of solid waste are generated from hides and skins during the tanning operation process. i.e. 1,918.228 tones from Sheba tannery if working at its full capacity, 86,567.22 tones from all tanning industries, 705.71 tones from the sampled shoe factories and 86.68 tons from the sampled garment and leather goods manufacturing industries. However, the means of solid waste leather disposal/utilization is almost negligently handled in Ethiopia without giving due attention to the health of the society as well as to the environment. Therefore it is vital issue to advise to properly dispose it in safe way/reutilize it as raw material to prepare for value added consumer products.

**Keywords:** Ethiopia; Hide; Skin; Leather; Solid waste; Pollution

### Introduction

The livestock population of Ethiopia according to the estimates of FAO, 2015 [1] is 55.694 million bovine, 26.537 million sheep and 25.035 million goats. These huge livestock numbers provide a strong raw material base for the leather and leather products industry of the country [2]. Hides and skins, which are renewable and easily perishable resources, are used as raw materials for the tanning industry [3]. These hides and skins constitute valuable material removed from the animal carcass. It is estimated that bovine hides represent 12% of the value of the animal [4]. The leather industry in Ethiopia is one of the top growing economic sectors and set in the front position by the Ethiopian government [5]. The country has 28 tanneries, 16 medium and large scale footwear manufacturers, 15 garments and goods factories, 3 gloves factories and 368 micro and small scale enterprises producing leather products [6]. This reality shows that Ethiopia is one of the most promising leather producing countries in Africa, which at the same time generates significant amount of solid waste leather and is costly transported to landfills with insignificant amount being sold to handicrafts business people [7].

Tanneries are generally pollution-intensive industrial complexes generating large volumes and high concentration of liquid and solid wastes. These wastes have historically been discharged in to rivers, land fill waste sites and to the air with little if any purification [8]. Inappropriate management of the tanning industry has detrimental effect on human health and the environment. Solid wastes generated from tanning industries contain different chemicals which are used during leather manufacturing process. These tannery solid wastes have different characteristics as different chemical and mechanical processes are applied to the raw hides/skins. If these solid wastes generated during various tanning operations are not properly utilized

or disposed of, they are very likely to cause a number of problems on the environment and human health. For instance, excessive chromium III uptake can cause health issues as skin rashes, stomach upset and ulcers, respiratory problems, weakened immune systems, kidney and liver damage, alteration of genetic material, lung cancer and death [9-11]. 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. Hair waste and lime sludge if discharged along with the effluents are likely to choke the drains. Raw and green fleshings, limed fleshings, splits (splitting waste) and trimmings putrefy easily and give rise to obnoxious smells. In many tanneries, it is the foul odour which emanate from some of these putrescible solid wastes that accounts for much of the smell traditionally associated with tannery wastes. Some of the biodegradable tannery solid wastes are sources of pathogenic bacteria and volatile organic compounds emission [12].

Though it is evident that improper management of the waste from the tanning industry is full of risk to the human and environmental health, presently almost all of the leftovers from leather product industries in Ethiopia and elsewhere are sent to the land fill as waste

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[13]. Mulat [14] described that environmental pollution becomes an alarming issue of the time in most parts of the world including Ethiopia. Leather industries in general give less attention to solid waste management and it is common to see heaps of illegally dumped wastes around rivers, tannery compounds and other open spaces. Burning of solid waste is also a common occurrence in many areas. There is no sorting of the solid wastes based on their properties and mixed solid wastes are disposed in open dumping sites.

The first step to managing solid leather waste is to estimate the actual amount generated during the production processes so as to design an appropriate waste disposal/reutilization method with minimum impact on the human and environmental health. The aim of this study is therefore to estimate the actual amount of solid waste leather generated from various tanning industries in Ethiopia.

### Methods

Secondary data is taken from Sheba tannery and computed to know the solid waste generation of hide, sheep skin and goat's skin. Questionnaires on the volume hide/skin used, grade of green hide/skin, pieces of product produced, consumption of hide/skin per product produced and total consumption were collected from three potential volunteer shoe companies located in Addis Ababa. Four year (2014 to 2017 G.C) data on raw hides and skin used from all tanneries was collected to measure the actual performance of tanneries and amount of waste generated annually. Observational measurement study was conducted by taking two hide from table rank (TR) and two from scar (SC) ranked samples from the three potential volunteer shoe companies to estimate solid waste generation rate. Each respondent was asked to provide the model type of the final product, number of products obtained from each raw material used (we used the total sample in ft<sup>2</sup> used for shoe making, amount of shoe prepared (indicates cutting value) and then by difference we computed generation rate). The study also considered garment and goods manufacturing companies located in Addis Ababa. Out of these only one factory having well organized four year data and volunteer to provide information was included in the survey purposely where as others are excluded for lack of accurately recorded data and for the reason that they are not volunteer to be included in the study/ are even not interested to provide information.

### Results and Discussion

The data presented in the Tables 1-4 shows the daily solid waste generation rate of hides and skins at Sheba tannery only.

#### Annual solid waste generation rate from sheba tannery

It can be seen from Table 1, that processing one tone of wet salted hide can generate 83.28 kg of solid wastes. The daily hide soaking capacity in Sheba tannery is 9000 kg and, as the factory has 275 working days per year, the annual soaking capacity is 2,475 tones of hide. Consequently, 206.118 tone of solid waste is generated annually during the overall tannery hide operations (from beam house to finishing processes).

As represented in Table 2, regarding sheep skins, processing one tone of sheep skin can generate 664.515 kg of solid wastes. The daily sheep skin soaking capacity of the tannery is 3,000 kg, and the annual soaking capacity is 825 tones of skin. Accordingly, 548.224 tone of solid waste is generated annually during the overall tannery sheep skin operations.

Finally, Tables 3 and 4 shows the case of goat skins in which processing one tone of goat skin can generate (433.46.96+322.30)

S/N	Type of waste	Weight(Kg)	Generation rate (kg/kg of wet salted hide)	Generation rate(kg/ton of wet salted hide)
1	Shacked salt	57.6	0.0043	0.43
2	Fleshings& Trimmings	1512	0.112	11.2
3	Unusable splits	586.72	0.0435	4.35
4	Wet trimmings(after sammying)	300	0.0222	2.22
5	Shavings	918.94	0.0681	6.81
6	Trimmings(Dry)	22.32	0.0017	0.17
7	Sludge	1702.08	0.1261	12.61
	<b>sub total</b>	<b>5099.66</b>	<b>0.3778</b>	<b>37.78</b>
8	Fleshings& Trimmings	2268	0.168	16.8
9	Unusable splits	879.41	0.0651	6.51
10	Wet trimmings(after sammying)	450	0.0333	3.33
11	Shavings	1378.44	0.1021	10.21
12	Trimmings(Dry)	33.84	0.0025	0.25
13	Sludge	1134	0.084	8.4
	<b>sub total</b>	<b>6143.69</b>	<b>0.4551</b>	<b>45.51</b>
	<b>Grand Total</b>	<b>10324.41</b>	<b>0.8328</b>	<b>83.28</b>

Table 1: Solid waste generated per day for 600 pieces of raw hide.

S/N	Type of waste	Weight(Kg)	Generation rate(kg/kg of wet salted sheepskin)	Generation rate(kg/tonne of wet salted sheepskin)
1	Raw Trimmings	550	0.0688	68.75
2	Shacked salt	78	0.0098	9.75
3	De-wooled hair	1,916	0.2395	239.5
5	Fleshings	2,320	0.29	290
6	Wet Trimmings	300	0.0375	37.5
7	Trimmings(Dry)	26.6	0.0033	3.325
8	Buffing dust	2.25	0.0003	0.28125
9	Trimmings(Dry)	2.45	0.0003	0.30625
10	Buffing dust	0.18	0	0.0225
11	Trimmings(Dry)	3.45	0.0004	0.43125
12	Buffing dust	8.1	0.001	1.0125
13	Shavings	76.5	0.0096	9.5625
14	Buffing dust	4.45	0.0006	0.55625
15	Off-cuts	17.77	0.0022	2.22125
16	Buffing dust	2.08	0.0003	0.26
17	Off-cuts	8.29	0.001	1.03625
	<b>Total</b>	<b>5,316.12</b>	<b>0.6645</b>	<b>664.515</b>

Table 2: Solid waste generated per day for 4000 pieces of Sheep Skin.

755.77 kg of solid wastes. Since the daily goat skin soaking capacity of the tannery is 5,600 kg, and then the annual soaking capacity is 1,540 tones of skin. Therefore, 1,163.886 tone of solid waste is generated annually during the overall tannery goat skin operations.

Therefore, a total of 1,918.228 tones of solid waste are generated annually by the company. At that point in time, the overall solid wastes generated are disposed to an open dumping area on the surrounding of the industry without any treatment. Therefore one can imagine how significant amount of waste is being disposed to the sounding without due consideration to the health of society as well as the environment.

### Tanneries

Table 5 show that during the study period 28 tanneries were in operation and almost all of these tanneries were performing half of

their installed capacities (67% for hide and 52.25% for skin). The data collected from the tanning industries confirmed that the solid wastes generated during the tanning process are as follow:-salt from hand shaking, fleshing, raw trimming (green trimming), hair (from hair shaving process), pelt trimming, wet blue split, dry sludge, chrome shaving and trimming, buffing dust, crust and finished leather scraps, the information obtained in this study is in agreement with previous reports on assessment and estimation of physical composition of the solid waste generated by tanneries [15-17]. The major reasons mentioned by the respondent companies for their low performance among others are absolute shortage and low quality of hide and skin, power failure, and shortage of spare parts. The annual processing performance was 7,607,180 pieces of hides and 88,449,648 skins. According to the information obtained from the tanneries during the questionnaire survey, the average weight of the Ethiopian cattle hide is 12 kg and that of skin 1.2 kg. Using the above conversion, 91, 286,160 kg (100,625.77 ton) of hide and 106,139,577.60 kg (116,998.86 ton) of skin is processed annually in all of the Ethiopian tanneries. Zulfikar [16] indicated that at ELICO (Ethiopian Leather Industry

Corporation) tannery one ton of wet salted hide solid wastes of 859 kg were generated which accounts for 86% of the raw hide processed. Similarly, Kanagraj et al. [18] reported that one ton of wet salted sheep skin generates 262.00 kg of solid waste which is 26.2% of the total weight of sheep skin processed. Zulfikar [16] noted that the processing of both raw hide and skin leads to the generation of 55.8 % solid waste. Using such benchmark and the current performance of the Ethiopian tanneries, an estimated 78,506,097.6 kg (86,538.16 ton) from hide and 26,363.95 kg (29.06 ton) from skin of solid waste or a total of 86,567.22 ton of solid waste is generated annually. Such solid waste is sent to land fill in the open environment without any careful consideration to the health issue of the community as well as to the environment (Figure 1).

### Shoe factories

As presented in Tables 6 and 7, the solid waste generation rate for hide and skin from shoe factories is estimated through observational survey (observation during cutting) by taking certain fast moving models of shoe conducted in the three volunteer potential shoe companies (for the reason that most companies are not volunteer to entertain researchers and provide information). The amount of solid waste generated varies greatly and largely depended on the quality of the raw materials, technology, the type of leathers produced, size of the product, and skill of the operators. The average solid waste generation rate for hide is 7.54% in the table rank (TR) (those having cutting value of greater than 50% that include materials having grades of I, II, III and IV). In case of scars (SC) those having cutting value of less than 50% and grade of V, VI and VII, gave generation rate of 26.48%. Totally the average solid waste generation rate (taking both ranks) is then 17.01%. The sampled Ethiopian shoe factories used 4,677,065.06 square feet (ft<sup>2</sup>) of hide and 6,565,885.61 square feet (ft<sup>2</sup>) of skin. Since the average area of Ethiopian skin is 5ft<sup>2</sup> and that of hide is 22ft<sup>2</sup>, then 4,126.94 ton of hide and skin is used annually in the sampled shoe factories. This is then translated to solid waste generation rate which is equivalent to 705.71 ton per annum. The results of this therefore somehow lower than the report of (Senthil, 2014), which indicates that in India, about 20-30% of leather is discarded as waste during footwear and leather goods production.

### Garment and goods manufacturing factories

In the case of garment and goods manufacturing factories, it is difficult to estimate the waste generation because of lack of properly recorded data and diversity of products (more than 200 different items) produced by the companies. To estimate solid waste amount, we therefore depended on one factory which has kept proper data. The average annual solid waste disposed from this factory was therefore estimated to be 82.68 tons of finished leather waste.

S/N	Type of waste	Weight(Kg)	Generation rate(kg / kg of wet salted goatskin)	Generation rate(kg/ tonne of wet salted goatskin)
1	Raw Trimmings	234	0.0975	97.5
2	Shacked salt	7.8	0.0033	3.25
4	Fleshings	600	0.25	250
5	Wet Trimmings	32.51	0.0135	13.5458
6	Trimmings(Dry)	0.98	0.0004	0.4083
7	Buffing dust	0.072	0	0.03
8	Trimmings(Dry)	4.45	0.0019	1.8542
9	Buffing dust	1.1	0.0005	0.4583
10	Shavings	110.5	0.046	46.0417
11	Trimmings(Dry)	1.915	0.0008	0.7979
12	Buffing dust	4.5	0.0019	1.875
13	Shavings	42.5	0.0177	17.7083
	<b>Sub Total</b>	<b>1,040.33</b>	<b>0.4335</b>	<b>433.4696</b>

Table 3: Solid waste generated per day for 1200 pieces of goat Skin.

S/N	Type of waste	Weight(Kg)	Waste generation rate(kg / kg of wet salted goatskin)	Waste generation rate(kg/ton of wet salted goatskin)
1	Raw Trimmings	14	0.0088	8.75
2	Shacked salt	-	-	-
4	Fleshings	480	0.3	300
5	Wet Trimmings	21.68	0.0136	13.55
	<b>Sub Total</b>	<b>515.68</b>	<b>0.3223</b>	<b>322.3</b>

Table 4: Solid waste generated per day for 800 pieces of Air-dried goat skin.

Year	No of tanneries in each year	Installed daily and annual soaking of tanneries				Performance			
		Installed daily soaking (23.3 working days in a month)		Installed annual soaking (280 working days)		%	hide	%	skin
		Hide	skin	hide	skin				
2014	30	9,050	141,500	2,534,000	39,620,000	60	1,520,400	53	20,998,600
2015	29	10,500	162,380	2,940,000	45,466,400	69	2,028,600	42	19,095,888
2016	28	10,500	162,380	2,940,000	45,466,400	83	2,440,200	52	23,642,528
2017	28	10,500	162,380	2,940,000	45,466,400	56	1,646,400	54	24,551,856
Total		40,550	628640	11,354,000	176,019,200		7,607,180		88,449,648
Annual average				2,838,500	44,004,800	67	1,901,795	50.25	22,112,412

Table 5: Installed daily and annual soaking capacities and performance of Ethiopian tanneries.



Figure 1: Solid waste disposed in tannery and shoe factory compounds.

Company code	Name of Raw material	No of samples taken	Grade of the sample		Model & shoe no		size of the sample taken (ft <sup>2</sup> )	pair of shoe obtained/ hide	Consumption/ shoe(ft <sup>2</sup> )	Total consumption	difference	Waste (%)	TR	SC
			TR	SC	Model	shoe no.								
A	Cow hide	1	√		E	39	14.5	5	2.68	13.4	1.1	7.59	7.59	
A	Cow hide	1	√		E	42	15.25	4.5	3.19	14.36	0.9	5.87	5.87	
A	Cow hide	1		√	E	39	9.25	2.5	2.68	6.7	2.55	27.57		27.57
A	Cow hide	1		√	E	42	12.25	3	3.19	9.75	2.68	21.88		21.88
B	Cow hide	1	√		927	42	12.75	2.5	4.17	11.78	0.98	7.65	7.65	
B	Cow hide	1	√		927	42	13	2.5	4.71	11.78	1.23	9.42	9.42	
B	Cow hide	1		√	927	42	12.5	2	4.71	9.42	3.08	24.64		24.64
B	Cow hide	1		√	927	42	11.75	1.75	4.71	8.24	3.51	29.85		29.85
C	Cow hide	1	√		M66	41	11.75	2	5.5	11	0.75	6.38	6.38	
C	Cow hide	1	√		M66	41	12	2	5.5	11	1	8.33	8.33	
C	Cow hide	1		√	M66	41	11.25	1.5	5.5	8.25	3	26.67		26.67
C	Cow hide	1		√	M66	41	11.5	1.5	5.5	8.25	3.25	28.26		28.26
Average												17.01	7.54	26.48

Note: E=Elgin (model) C, TR= table rank (grade I, II, III, IV); SC=scar (grade V, VI, VII); TR and Scar is the name given by the shoe factories to measure the leather quality (grade level).i.e. TR= leather having cutting value of greater than 50% but SC= leather having cutting value of less than 50%.

Table 6: Solid waste generation rate for hide.

Company code	Name of Raw material	No of sample taken	Grade of the sample		Model & shoe no		size of the sample taken(ft <sup>2</sup> )	pair of shoe obtained/ skin	Consumption/ shoe(ft <sup>2</sup> )	Total consumption	difference	Waste (%)	TR	SC
			TR	SC										
A	skin	1	√		ETHY	36	5.15	2.00	2.35	4.70	0.45	8.74	8.74	
A	skin	1	√		ETHY	36	5.25	2.00	2.35	4.70	0.55	10.48	10.48	
A	skin	1		√	ETHY	37	4.50	1.50	2.44	3.66	0.84	18.67		18.67
A	skin	1		√	ETHY	37	4.55	1.50	2.44	3.66	0.89	19.56		19.56
B	skin	1	√		6202	42	3.25	1.25	2.30	2.88	0.38	11.54	11.54	
B	skin	1	√		6202	42	3.30	1.25	2.30	2.88	0.43	12.88	12.88	
B	skin	1		√	6202	42	3.00	1.00	2.30	2.30	0.70	23.33		23.33
B	skin	1		√	6202	42	3.15	1.00	2.30	2.30	0.85	26.98		26.98
C	skin	1	√		1577	42	6.00	2.00	2.70	5.40	0.60	10.00	10.00	
C	skin	1	√		1577	42	6.25	2.00	2.70	5.40	0.75	12.20	12.20	
C	skin	1		√	1577	42	5.50	5.50	2.70	4.05	1.45	26.36		26.36
C	skin	1		√	1577	42	5.25	5.25	2.70	4.05	1.2	22.86		22.86
Average												16.97	10.97	22.96

Note: E=Elgin (model) C, TR= table rank (grade I, II, III, IV); SC=scar (grade V, VI, VII)

Table 7: Solid waste generation rate for skin.

## Conclusions and Recommendations

In this study we concluded that remarkable amount of solid waste is generated from the tanning industry and the same is sent to the land fill without due consideration to the environmental and society health issues or giving no attention to its economic benefit as it can be converted in to value added consumer products. As a recommendation due attention should be given to change this significant amount of solid waste leather from threat to an opportunity that can serve as resource and converted in to value added consumer product and this sustainably can reduce environmental pollution in addition to its economic benefit.

**Conflict of Interest:** The authors declare that there is no conflict of interest.

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