

RESEARCH ARTICLE

Generation of leather offcuts in the Ghanaian footwear industry

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Abstract

Despite the contributions of the footwear industry to livelihoods and to the provision of useful products in society, waste from footwear production is toxic and can cause harm to humans if not managed well. This study attempts to quantify the leather offcut generation rate in Ghana's footwear industry and examine factors that contribute to it. Using a quantitative approach and a descriptive correlational research design, the study focused on local footwear producers in Kumasi and Tamale. Results from the study showed a statistically significant difference in the leather offcut generation rate of footwear producers in Kumasi (M = 0.23kg, 0.21kg for two production cycles respectively) in comparison to producers in Tamale (M = 0.12kg, 0.11kg for two production cycles respectively). Additionally, there is a significant relationship between leather offcut generation and production duration, production quantity and footwear type, specifically female slippers and sandals. The study concludes that waste from leather offcuts is sizeable and should be given attention bearing in mind that it is influenced by scale-related variables and internal production dynamics.

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1. Introduction

Waste generation has been with us for a long time. Innovation and rapid growth of the human population has multiplied the quantity of waste generated in society (Weinberg et al., 2000). While waste before industrialization was largely non-toxic and small in quantity (Barles, 2014), waste today is huge, toxic, hazardous and non-biodegradable. Several studies have flagged the footwear industry as major contributor to hazardous waste with negative effects on human health and environment (Jiang et al., 2008 & Balamurugan et al., 2014). According to Ingre-Khans, Rudén, and Breitholtz (2010), waste from footwear production like shoe soles are toxic and risky. Nevertheless, the footwear production industry contributes significantly to livelihoods (Boahin, 2008). Thus, debates on industrial leather waste from tanning processes and leather products manufacturing emphasize the need to balance environmental impact and economic value through circular economy practices to obtain a net positive output.

The transition from negative to positive outcomes in footwear production is made possible by grounding this study on principles within the Waste Management Theory (WMT) propounded by Pongrácz (2006). Situated in industrial ecology, WMT argues that waste has a dynamic and temporal nature that is influenced by four key attributes: purpose, structure, state and performance. WMT places the onus of waste management on the owner of the outcome of an industrial process who has the responsibility to conserve resources and minimize loss, prevent waste through efficient processes or convert waste into non-waste through the assignment of a purpose. WMT further acknowledges that although the structure of an artefact may be damaged through use putting it in a state where its characteristics hinder performance, the owner is responsible for ensuring repair; and sometimes retrievability from the original owner to a new owner is necessary (Pongrácz, 2006). Thus, it can be inferred that waste management is usually effective when there is an understanding of waste generation activities including who generates the waste, how much waste is produced and the generation frequency. Additionally, the emphasis on process and resource optimization could imply interactions between production duration, production quantities and waste generation. Inefficient processes over longer production durations could yield higher waste generation while optimised resources could contribute less waste even when production quantities are increased. However, researchers (Vidal, 2021; Asamoah, 2023) suggest inefficiencies in the African footwear industry due to manual processes, limited use of machinery and mechanical development gaps; thereby, hinting that increased production quantities could likely lead to increased offcut production.

Research by UNIDO (2000) and Senthil et al. (2014) indicate that the largest quantity of industrial waste is generated at the cutting stage of the production process with 20% to 35% of leather used in footwear production becoming waste. Nevertheless, the quantity of waste

generated in footwear production can vary depending on factors such as material assembling technology employed, type of footwear (UNIDO, 2000), quality, type and size of material used, size of the footwear and skill of the manufacturer (Teklay et al., 2018). In addition, waste generation in footwear production is reported to be higher for safety shoes followed by women's, men's and children's shoes (UNIDO, 2000). In the UNIDO (2000) study, waste generated for a million pairs of safety shoes totalled 520 tons while that for men, women and children stood at 233, 242 and 152 tons respectively (UNIDO, 2000). Waste generated from leather uppers and lining material contributed the most to these totals. Nevertheless, quantities recorded appeared higher for men's shoes, totalling 96.2 tons in comparison to women's shoes (70.6 tons). While these studies are vital, they are outdated with literature on the generation of footwear related waste in Ghana is almost non-existent.

Regarding industrial solid waste generation, Krones et al. (2020), found similarities in the annual quantity of non-hazardous solid industrial waste generated in the US in comparison to municipal solid waste generation. Of these, solid wastes from textile, apparel and leather products ranged from 0.5 to 0.7 teragram (Tg) annually. Although Mesjasz-Lech (2025) found decreasing waste generation in manufacturing companies within Europe, the same cannot be said of African countries where institutional frameworks and governance mechanisms for enforcing waste management policies are weak (Godfrey et al., 2019). Unfortunately, studies on waste generation in Ghana and Africa (Fobil, 2006; Miezah et al., 2015; Addo & Wahabu, 2019; Oteng-Ababio et al., 2023) focus on households rather than producers. For industrial waste, Oduro-Kwarteng et al. (2021) discovered that waste management practices in the Ghanaian healthcare industry fell below international best practices with waste generation per bed for Kumasi ranging from at 0.76 to 2.92kg for hospitals and 0.012 to 0.008kg for community health centres. Data on waste generation rates in other industries including the leather products industry is not available in literature.

Concerning municipal solid waste, Oteng-Ababio et al. (2023) found rates ranging from 0.40 to 0.89kg per person per day in literature with Accra recording higher figures. Miezah et al. (2015) reported an average household waste generation rate of 0.47kg per person per day on a national level. In their study, organic waste constituted most of the waste generated by households. In contrast, recyclable waste, which included leather products that had reached their end-of-life cycle, totaled only 0.096kg per person per day (Miezah et al., 2015). Seshie et al. (2020) also found that leather and rubber made up only 1.2% of the total waste they collected and characterised in Takoradi. These estimates are quite low when compared with other recyclable waste like plastic, paper, metals, and glass. Fobil (2000, cited in Fobil, 2006) observed a generation rate ranging from 0.016kg to 0.035kg per person per day for plastic waste which makes up the largest component of recyclable waste. Miezah et al. (2015) also discovered differences in waste generation quantities between metropolitan and municipal cities in Ghana, with metropolitan cities generating more waste. Despite this, their study also found that waste

generation in Tamale was considerably low in comparison to its metropolitan city counterparts. In another study by Addo and Wahabu (2019), the waste generation rate in a suburb of Tamale was estimated at 0.3148kg per person per day and this included mostly organic waste.

The objective of this study is to 1) investigate the generation rate of leather offcuts (LOs) by local (artisanal) footwear producers (LFPs) in Kumasi and Tamale and 2) assess the relationship between leather offcut generation and production duration, production quantity, and footwear type. Inferring from the literature review and the WMT, the following hypotheses were formulated and tested:

H1: Leather footwear producers in Kumasi will produce more leather offcuts than leather footwear producers in Tamale.

H2: There will be a significant positive relationship between production duration and leather offcut generation.

H3: There will be a significant positive relationship between production quantity and leather offcut generation.

H4: There will be a significant positive relationship between footwear type and leather offcut generation.

2. Method

2.1 Research Design

The study adopted a quantitative research approach. A descriptive correlational research design (Miksza et al. 2023) was used because it allowed the researcher to investigate issues as they were among respondents and assess relationships objectively (Cresswell, 2012).

2.2 Participants

The population of the study included 1) LFPs in 10 cluster markets in Kumasi and 2) LFPs in the Hausa Zongo community in Tamale. The footwear production clusters included were the 31st, Abinchi, Asafo, Bantama, Mooro, Atonso, Pankrono, Akokodweso, Patasi, and Afful Nkwanta markets. The snowball and purposive sampling techniques were employed to select the participants for the study. This was due to the unavailability of information on the sampling frame to allow for the use of a probability sampling technique. Naderifar et al. (2017) argue that snowball sampling is an appropriate technique to use when access to respondent is difficult due to limited data on the population size. Additionally, the technique provides the advantage of openness on the part of the respondent resulting from their acquaintance with the initial respondent (Naderifar et al., 2017). Purposive sampling also ensured that the sample comprised of respondents who specialized in the production of varied footwear types. A total of 220 LFPs

from Kumasi, 32 LFPs from Tamale were sampled and included in the study. Although the sample size for Tamale seems relatively small, it represented about 80% of the population of footwear producers in the region.

2.3 Instrumentation

Data collection was conducted using a questionnaire. The questionnaire captured information on the characteristics of respondents and their businesses and on the leather offcuts generated from footwear production. Waste estimation was done in two stages. First, respondents were asked to specify, on the questionnaire, the container they use to collect and store leather offcuts. Second, respondents estimated on the questionnaire how full their waste collection container was for the last two production cycles using a scale of full, three-fourths full, half full, and a quarter full. Next, the researcher filled each container type with leather offcuts to full capacity and weighed them to establish the kilogram equivalents of the four point scale. The weight of each container, when full, was divided into four to determine the weights of each container when quarter full, half full, and three-fourths full. Weighing resulted in the kilogram equivalents presented in Table 1 which were used for the analysis. Reliability and content validity was ensured by giving the questionnaire to experts to review; and amendments carried out to reflect their feedback.

Table 1: Kilogram Equivalents of the Scale for Estimating the weights of LOs

SCALE	KG EQUIVALENT	SCALE	KG EQUIVALENT
Plastic Bag (20p)		Sack (Size 4)	
Quarter Full	0.3125kg	Quarter Full	2.5kg
Half Full	0.625kg	Half Full	5kg
Three-fourths Full	0.9375	Three-fourths Full	7.5kg
Completely Full	1.25kg	Completely Full	10kg
Plastic Bag (50p)		Sack (Size 5)	
Quarter Full	1.25kg	Quarter Full	3.75kg
Half Full	2.5kg	Half Full	7.5kg
Three-fourths Full	3.75kg	Three-fourths Full	11.25kg
Completely Full	5kg	Completely Full	15kg

Source: Author, 2021

2.4 Data Analysis

Data analysis was conducted using descriptive and inferential statistics (Ali & Bhaskar, 2016). Descriptive statistics, specifically mean and standard deviation, were used to describe the characteristics of the local footwear producers and their businesses and to calculate the generation rates of leather offcuts. Inferential statistics, using SPSS version 25, specifically the independent-sample t-test and a correlation matrix, were employed to compare the means of waste generation rates based on geographic location, and to examine the relationship between waste generation and measured variables like production duration, production quantity, and footwear type.

3. Results

3.1 Background Characteristics

Local footwear producers included in the study operated within ten clusters of markets in Kumasi with most of them (46 out of 220) based in the Abinchi market. Only 9 of the footwear producers in the Akokodweso market were part of the study. Most of the footwear producers reported having been operating in the industry for more than 10 years with a few (31 out of 220) indicating industry experience of more than 20 years. This finding could imply a higher level of expertise and skills which according to the literature, can influence the quantity of waste generated. Sandal and slipper production dominated the productions activities of the respondents with almost half of them (48.8%) specializing in female' sandals and slippers. Shoe production was minimal and only a few respondents (10%) specialized in children's footwear. Some respondents also had multiple production lines. In Tamale, the local footwear producers involved were drawn from one cluster market i.e the Hausa Zongo cluster. Findings indicated that most of the respondents had been in the business for more than ten years with 10 out of the 32 footwear producers having more than 21 years of experience. All the footwear producers specialized in the production of unisex sandals and slippers; with 14 of them involved in children's footwear as an additional product line. Production of shoes did not feature as a product line among respondents in the Tamale metropolis.

3.2 Leather Offcut Generation Rate

Findings from the descriptive analysis (see Table 2) showed that on average, footwear producers in Kumasi spent nearly five days longer in completing a production cycle when compared with footwear producers in Tamale. Nevertheless, production duration in Kumasi showed wider variability, with cycle lengths ranging from 3 to 48 days, whereas Tamale ranged from 6 to 12

days. Additionally, the study revealed that although average production quantity for footwear producers in Tamale was higher for cycle one, the leather offcuts generated for that cycle was less in Tamale (than in Kumasi. This translated into an adjusted daily waste of 0.23kg and 0.12kg for footwear producers in Kumasi and Tamale respectively.

Table 2: Descriptive Analysis										
				95% CI						
	Region	N	Mean	Lower	Upper	Median	SD	Min	Max	
Dur.1	Kumasi	220	14.14	13.30	14.97	12.00	6.28	3	48	
	Tamale	32	9.10	8.34	9.85	9.00	2.08	6	12	
1st_PQ	Kumasi	213	359.67	316.13	403.21	250	322.36	30	2000	
	Tamale	32	419.06	273.72	564.40	275.00	403.12	30	2000	
Wste1(kg/cycle)	Kumasi	220	2.93	2.67	3.18	2.50	1.90	0.63	11.25	
	Tamale	32	1.06	0.88	1.23	1.10	0.48	0.31	2.50	
Wste1(kg/day)	Kumasi	220	0.23	0.21	0.25	0.21	0.16	0.03	0.94	
	Tamale	32	0.12	0.10	0.14	0.10	0.06	0.05	0.31	
Dur. 2	Kumasi	220	14.16	13.19	15.12	12.00	7.27	2	72	
	Tamale	32	9.22	8.38	10.06	9.00	2.32	6	12	
2nd_PQ	Kumasi	213	312.90	272.75	353.05	200	297.27	20	2000	
	Tamale	32	305.31	225.36	385.27	250.00	221.77	30	1000	
Wste2(kg/cycle)	Kumasi	220	2.62	2.38	2.87	2.50	1.86	0.63	11.25	
	Tamale	32	0.96	0.77	1.14	0.94	0.51	0.31	2.50	
Wste2(kg/day)	Kumasi	219	0.21	0.19	0.22	0.21	0.14	0.03	0.83	
	Tamale	32	0.12	0.08	0.13	0.10	0.06	0.03	0.31	

Regarding production cycle two, the study's results again indicated a longer production duration for footwear producers in Kumasi, with a broad range of 2 to 72 days, while average duration for producers in Tamale remained at 9.22 days with some recording a minimum of 6 and maximum of 12 days. Production quantities were similar in both regions for cycle two. Even though production quantity for Kumasi was only slightly higher than that for Tamale this time, waste produced for cycle two was higher in Kumasi than in Tamale. These figures translated into an adjusted daily waste of 0.21kg and 0.11kg for footwear producers in Kumasi and Tamale respectively. These results indicate that Kumasi experienced longer and more variable production

cycles, alongside higher waste levels, while Tamale displayed shorter and fairly stable production cycles with comparatively lower waste outputs.

3.2.3 Comparison for Waste Generation by Geographical Location.

To test for the first hypothesis, which stated that leather footwear producers in Kumasi will produce more leather offcuts than leather footwear producers in Tamale, an independent t-test was conducted. The data in Table 3 shows a clear and consistent difference between the two locations, with Kumasi producing more waste than Tamale in both cycles. More importantly, the magnitude of the observed differences is substantial. In the first cycle, the effect size falls within the range conventionally interpreted as large, indicating that the difference is not only statistically significant but also practically meaningful. The associated 95 percent confidence interval suggests that the true effect is unlikely to be small and reflects a robust separation between the two locations. A comparable pattern emerged in the second cycle, where the effect size increased slightly to .76. These effect sizes indicate that location accounts for a considerable proportion of the variation in leather offcut generation. This strengthens the inference that the observed differences are driven by systematic contextual factors. On this basis, H1 was supported.

Table 3: Independent t-test table showing the differences in waste generation by geographical location.

Variable	N	Mean	SD	T	Effect Size	Sig	95% CI	
							Lower	Upper
First Cycle Waste (kg/day)								
Kumasi	220	.23	.16	3.91	.74	.001	.36	1.12
Tamale	32	.12	.06					
Second Cycle Waste (kg/day)								
Kumasi	219	.21	.14	3.97	.76	.000	.38	1.13
Tamale	32	.11	.06					

3.3 Factors Influencing Leather Offcut Generation

3.3.1 Production Duration and Leather Offcut Generation

The second hypothesis which stated that production duration will be positively associated with leather offcut generation was examined using the Pearson r correlation. In the first cycle, duration showed a moderate positive association with waste produced per cycle. However, duration showed a small negative correlation with daily waste, reflecting a dilution effect where

longer cycles produced less waste per day despite higher overall accumulation. The second cycle also revealed a similar pattern but with slightly stronger effects.

Table 4: Correlation Matrix

	Dur.1	Wste1(kg/cycle)	Wste1(kg/day)	Dur. 2	Wste2(kg/cycle)	Wste2(kg/day)
Dur.1	—					
Wste1(kg/cycle)	0.447 ***	—				
Wste1(kg/day)	-0.204 **	0.645 ***	—			
Dur. 2	0.743 ***	0.292 ***	-0.142 *	—		
Wste2(kg/cycle)	0.412 ***	0.686 ***	0.410 ***	0.431 ***	—	
Wste2(kg/day)	-0.095	0.511 ***	0.713 ***	-0.168 **	0.682 ***	—

Note. * p < .05, ** p < .01, *** p < .001

Duration was positively related to waste per cycle ($r = .431, p < .001$), indicating that extended second-cycle operations corresponded with higher total waste. Nevertheless, as in the first cycle, duration correlated negatively with daily waste ($r = -.168, p < .01$), suggesting decreased waste generation per day despite increasing waste per cycle. Considering that the entire associations between production duration and leather offcut generation were not positive, H3 was partially confirmed.

3.3.2 Production Quantity and Leather Offcut Generation

As shown in Table 5, production quantity for the first cycle was moderately associated with waste produced per cycle ($r = .544, p < .001$). This indicates that units with higher output tended to accumulate more total waste across the cycle.

Table 5: Correlation Matrix

	1st_PQ	Wste1(kg/cycle)	Wste1(kg/day)	2nd_PQ	Wste2(kg/cycle)	Wste2(kg/day)
1st_PQ	—					
Wste1(kg/cycle)	0.544 ***	—				
Wste1(kg/day)	0.245 ***	0.645 ***	—			
2nd_PQ	0.729 ***	0.477 ***	0.225 ***	—		
Wste2(kg/cycle)	0.519 ***	0.686 ***	0.410 ***	0.764 ***	—	
Wste2(kg/day)	0.286 ***	0.511 ***	0.713 ***	0.403 ***	0.682 ***	—

Table 5: Correlation Matrix

	1st_PQ	Wste1(kg/cycle)	Wste1(kg/day)	2nd_PQ	Wste2(kg/cycle)	Wste2(kg/day)
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Note. * p < .05, ** p < .01, *** p < .001

The link between production quantity and daily waste was weaker but still positive ($r = .245$, $p < .001$), suggesting that higher output corresponded with only a small increase in waste generated each day. In the second cycle, these associations strengthened considerably. Production quantity correlated strongly with waste per cycle ($r = .764$, $p < .001$), reflecting a pronounced increase in total waste as output rose. The relationship between production quantity and daily waste was moderate ($r = .403$, $p < .001$), again showing that producers making more footwear generated more waste on a daily basis. Therefore, the study confirmed H3 which stated that there will be a significant positive relationship between production quantity and leather offcut generation.

3.3.3 Footwear Type and Leather Offcut Generation

The average of the waste generated in both cycles was computed (see Table 6). Female sandals and slippers exhibited a small positive relationship with average waste ($r = .117$, $p < .05$), indicating that units producing this category tended to generate slightly higher waste. However, the rest of the footwear types (shoes for varied demographics and sandals and slippers for male and unisex audiences) showed no direct association with average waste. Thus, H4 which stated that there will be a significant positive relationship between footwear type and leather offcut generation was partially supported.

Table 6: Correlation Matrix

	Average Waste	ShoesMales	ShoesFemales	ShoesUnisex	SanSlipMales	SanSlipFemales	SanSlipUnisex
Average Waste	—						
ShoesMales	0.027	—					
ShoesFemales	-0.004	-0.013	—				
ShoesUnisex	0.062	-0.022	-0.006	—			
SanSlipMales	-0.007	0.021	-0.022	-0.038	—		
SanSlipFemales	0.117 *	-0.189 **	-0.060	-0.036	-0.296 ***	—	

Table 6: Correlation Matrix

	Average Waste	ShoesMales	ShoesFemales	ShoesUnisex	SanSlipMales	SanSlipFemales	SanSlipUnisex
SanSlipUnisex	-0.004	0.046	-0.044	0.066	-0.213 ***	-0.722 ***	—

Note. * p < .05, ** p < .01, *** p < .001

4. Discussion

4.1 Leather Offcut Generation

Results from the study shows higher leather waste generation rates in comparison to figures reported by Miezah et al. (2015) where waste generation rate for leather was less than 0.096kg per day. This finding may be due to the study’s focus on industrial waste rather than household waste. When compared with industrial waste generated in the health sector (Oduro-Kwarteng et al., 2021), this study found comparable figures for both Kumasi and Tamale as mean leather offcuts generated per day was higher than waste generated per bed per day for community health centres (0.012kg to 0.008kg) though lower for hospitals. Leather offcuts per day estimated from the study were also comparable to the plastic waste generation rate range of 0.016kg to 0.035kg reported by Fobil (2000, cited in Fobil, 2006); and this mirrors findings by Kronos et al. (2020) who found similarities in the quantity of industrial waste generated per annum in comparison to municipal sold waste generated in the US. Additionally, the study indicated differences in waste generation rates for leather offcuts based on location with footwear producers in Kumasi generating more leather offcuts than producers in Tamale. This difference is not surprising as Miezah et al. (2015) observed lower levels of waste generation for different waste types in Tamale in comparison to other metropolitan cities. Perhaps, waste generation was also lower because footwear producers in the Tamale specialized only in unisex sandals and slippers, which did not have a statistically significant relationship with offcut generated per findings of this study.

The fact that waste generation was higher for producers in Kumasi, despite lower production quantities, suggests the presence of location specific factors. An analysis of background characteristics of footwear producers in the Kumasi region revealed that most of the them had at least 10 years of experience in the business; therefore, we could argue that cutting skill may not be the issue although Teklay et al. (2018) also hinted that this was a factor that influenced offcut generation rate. Thus, there may be other factors like production technology or leather type and size (UNIDO, 2000) contributing to the waste generated. Engagements with the

producers in Kumasi showed a dominant use of imported leather scraps which come in irregular shapes and small sizes that could make cutting specific patterns difficult. Despite these findings, the study acknowledges that the disparity in sample size for Kumasi and Tamale could weaken the extent to which the findings can be generalized beyond the studied contexts.

4.2 Factors Influencing Leather Offcut Generation

Despite the observance of a statistically significant relationship between production duration, production quantity and leather offcut generation, the raw data revealed exceptions which played out as some producers reported higher leather offcut generation even for shorter durations and lower production quantities. In some instances, the offcuts generated varied from low to high even though production quantity and duration stayed the same for the producers. Additionally, findings on the partial correlation between production duration and offcut generation suggests that other factors aside inefficiencies in the production process as indicated in the WMT influence waste generation. The negative correlation observed for daily offcut generated could imply benefits, from repeated production, to producer skill. This may be evidence of learning on the part of footwear producers who may have improved with cutting and production related activities or progressed from experimentation in the early stages of production. Thus, waste may likely be less if a footwear producer specialised in a particular design and repeated it overtime in large quantities. Nevertheless, this and other factors like leather quality, cutting technology, and design complexity highlighted by Teklay et al. (2018) as factors contributing to offcut generation would have to be investigated further and controlled for in future studies to enable causal interpretability.

The statistically significant relationship between the production of female sandals and slippers help provide further explanations for why the waste generated in Kumasi may have been higher even though production quantity was less in comparison to that by producers in Tamale. With almost 50% of the footwear producers in Kumasi specializing in female sandals and slippers, it is possible that their production required more complex designs with curved edges, irregular shapes and decorative elements that led to the generation of more offcuts. This mirrored findings by UNIDO (2000) on the role of footwear types in waste generation where they found that the waste generated for a million pairs of footwear was slightly higher for women footwear than for men's footwear.

5. Conclusion

This study set out to fill an empirical and geographical gap in literature by quantifying leather offcuts generated in two footwear production hubs in Ghana and to assess the factors influencing its production. Based on the results, the study concludes that the scale of leather

offcut generation, from an industry perspective, is sizeable and warrants attention. On one hand, this has positive implications for raw material sourcing for leather recycled artists; however, an efficient collection and handling mechanism is needed to achieve net positive outcomes. On the other hand, this conclusion signals an alarming threat to society as these offcuts, if not managed properly could end up in water bodies with negative consequences to human health. Regarding the factors that influence leather offcut generation, the study concludes that while scale-related variables are important, there are also internal production dynamics that should be considered with issues about what is produced and who it is produced for important.

Inferring from the WMT, the study proposes that increasing leather offcuts need not stay waste but be repurposed. Firstly, footwear producers need to rethink footwear design, especially for female sandal and slippers to ensure that new designs support resource optimization. Creating new designs could take the form of annual competitions among students and leatherwork practitioners. Secondly, academic institutions training leather practitioners should introduce interventions that improve the efficiency of production processes and sharpen the cutting skill of artisanal leather products manufacturers. Additionally, training interventions should include a course on designing for waste based on its characteristics to enhance the usability of leather offcuts of different shapes, sizes and thickness. Thirdly, policy makers should create a funding mechanism to support more research on industrial leather waste and sustainable solutions. Commercialization of new footwear designs will require, thorough research to understand the needs, tastes and preferences of customers and the strategies to employ to convince footwear producers and users to embrace change. Finally, policy makers should incentivize sustainable design initiatives, for example through tax rebates, among footwear producers in the country.

While, the indirect quantification approach coupled with variability in leather density and offcut sizes across producers could limit precision, this study serves as one of the few studies addressing an underexplored but policy relevant issue on industrial leather waste generation. Considering the concerns of leather waste toxicity in global debates, the originality of this study comes from its focus on artisanal small-scale industrial production waste in contrast to the emphasis placed on household waste by most waste management studies in Ghana.

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