

## Research Article

# Design and Development of Appropriate Tyre Sandal Shoe: Case of Rural Peoples around Bahir Dar city

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### Abstract

The current study was conducted with the objective of designing and developing appropriate tyre sandal shoe for rural people around Bahir Dar city, Ethiopia. The study was carried out through questionnaire, interview and observational study. The researcher identified the existing situations and problem happened on tyre sandal users in the area. The current tyre sandal worn by rural people around Bahir Dar city not comfortable for their feet, due to rough surface and hardness of tyre straps and it caused a dry foot and foot crack related problem around their forepart and heel area of foot. More specifically, these tyre sandals are heavy in weight and the straps frequently tend to break at the connecting points, due to poor nail or tack attachment of tyre sole and tyre straps. Based on data analysis, the researcher designed and developed four appropriate shoe collections. Target group showed their willingness to use all shoe collection. The Author gave training on production of new shoe collection for tyre sandal producers in the area. Some of the target users who faced foot crack related problem used the new shoes and the author observed that the new shoes protected the target users feet from dirt and bacteria.

**Keywords:** Automotive tyre; Footwear; Tyre sandals; Cows hides; Shoe design; Shoe development.

### Introduction

Shoe is any foot covering made of various kinds of material or combination of materials like leather, canvas, rubber, textiles, wood, synthetics and unused tyre to protect from cold, heat, thorns, hazards etc and to serve as a consume in the form of sandal, shoe or boot [1,2]. Tyre is a complex mixture of chemically cross-linked different rubbers, such as: natural rubber, styrene-butadiene rubber and polybutadiene rubber, steel cords, other polymeric fibers, carbon black, other organic and inorganic compounds [3]. Annually about 1.5 billion tyres are produced and around 1 billion tyres (17 million tonnes) [4] reach their end of life worldwide [5]. Dumping of waste rubber products is becoming an environmental challenge in several developing countries due to their non-biodegradability characteristic. Majority of waste rubber products are generated from damaged or scratched automotive tyres and industrial conveyor belts [6]. The technology to turn a potentially hazardous waste product (i.e., scrap tyres) into a valuable resource is available now. Scrap tyres are used for a variety of

applications including: noise barriers, construction applications, artificial reefs, fuel, road paving mix, sports surfaces, roofing, solid rubber wheels, burning as fuel, burning for the steel, cutting for the nylon cord, tire sandals and more [7].

In Ethiopia, the amount of waste tyres generated is expected to grow with the increase in the vehicle fleet in the country. In the country disused materials including tyres, plastic bottle and rope are recycled into different products [8]. A very interesting solution in tire recycling was developed by the Solerebels Company of Ethiopia, which produces footwear with soles made from suitably shaped pieces of tyre treads. The company was created by Ethiopian entrepreneur Bethlehem Tilahun Alemu in 2005 [9,10]. The business is recognized for its ethical production [11,12], including Fair Trade practices and the use of sustainable materials in its manufacturing, particularly its use of recycled tires for the soles of its shoes [13,14] Currently Solerebels Company is producing Light weight, fully fashioned, modern style that made from used tires and fabric but the sandals are

expensive, due to this the company is not meeting the demand of rural peoples around Bahir city.

In Bahir Dar city area disused tyres are widely available in different car maintenance workshops. Recycled tyre sandals are well known in most rural people who is living in the area, due to durability of tire soles and the amount of walking pastoralists (people who raise livestock and farming for a living) have to do to survive. These tyre sandals are open heeled and open toe cap type of footwear, consisting of a tyre sole held to the wearer's foot by tyre straps going over the instep girth and back counter. These tyre sole and tyre straps are attached by using small nails or tacks. Usually wearing this type of tyre sandal shoe can expose peoples for foot crack, dirt and bacteria and their foot is prone to infection because, debris can get into the cracks of the skin. Cracked heels and forepart are common foot problem, resulting from callused and dry skin. There are a number of predisposing factors which make heel fissures more likely to occur. Cause of foot crack include the presence of abnormally dry skin, corns or calluses, prolonged standing (especially on hard surfaces), excess body weight, going barefoot or regularly wearing sandals or open-backed shoes [15] [16].

Open-heeled shoes that expose the heel of the foot are among the leading causes of cracked heels Heels and toecap (forepart) are common place that cracks can develop. A dry foot is a common problem that can become painful if deep cracks developed at back of heel. These deep cracks can become so painful that it hurts to walk. If the cracks are deep, it may even bleed [17]. As shown in fig. 1, if somebody's feet are very dry and it has cracked feet at the heel and forepart, it will increase the risk of having diseases through the feet cracks.



Fig. 1. Forepart and heel area foot crack related problem and tyre sandal (Photo shoot by Author)

As reviewed in different literatures, the researcher studies the effect of open heeled tyre sandal on the feet. In order to improve the effect

tyre sandal it is required to design and develop appropriate shoe which protect heel area and made from breathable materials to maintain hydration and control excessive sweatiness of the feet. This study is carried out by identifying the existing situations and problems related to tyre sandals in the area. The author selected new model and developed appropriate shoe for the target peoples.

## Materials and methods

### Materials

The researcher selected locally treated cow hide for shoe upper making, because it is breathable, durable, water resistant, cheap, easily available and easily stretch during lasting. Scrap tyre is selected for shoe out sole because it also durable, cheap, and has good abrasion resistance and easily available in the area.

### Methods

The population of this research was restricted to rural people tyre sandal users around Bahir Dar city. In the area there are 5 local tyre sandal producers. Based on preliminary study and interview made with tyre sandal producers and users, tyre sandals produced in the area lasts for 4 months. The monthly production of single tyre sandal producers estimated 50 tyre sandals and equals 200 tyre sandals per 4 months. The total tyre sandal produced by 5 tyre sandal producers estimated 1000 tyre sandals. Based on Yamane published table [18], sample size for  $\pm 10\%$  precision levels and 95% confidence level of 1000 population has a sample size of 91. The researcher distributed 110 questionnaire papers (i.e. 91 + 20% of 91) for tyre sandal users in the area.

Respondent result showed that most of tyre sandal users selected wearing tyre sandal, due to tyre sole strength and it is cheaper sandal shoe in the area. However, these tyre sandals have several defects or disadvantages. This shoe is heavy in weight compared to other sandal shoe in the area and more than 40% respondent faced foot crack related problem. Mostly they feel discomfort during walking; due to rubbing of rough tyre strap surface of their feet. More specifically, the tyre straps frequently tend to break at the connecting points; due to poor nail or tack attachment of tyre strap and tyre sole. This indicated that the design, material type, nail attachment or construction method of current tyre

sandal shoe requiring focus and priority area for further modification.

### **Main consideration points of appropriate shoe Design**

The researcher focused on designing and developing appropriate shoe that protects heel and forepart area from foot crack related problem. The collection are made from breathable material in order to fulfill target users requirement by considering shoemaking standards, comfort, durability, aesthetic appearance, fitting, cost and market.

### **Mean form making (masking)**

Masking is a process of attaching adhesive tape (Scotch tape) on Last. The researcher selected 42 sizes last and produced a Mean formed by using a scotch tape or adhesive tape and A1 size paper.

### **Tools required for shoe designing and making**

The researcher used cutting matt, cutter, pincer, pencil, puller, tacks, rampi and other accessories for shoe making. As shown in fig. 2, the researcher designed four shoe collections based on produced mean formed by following standard shoe making procedure. The collections are closed forepart with closed counter shoe, partially closed vamp with closed counter shoe, closed forepart with open counter shoe and closed counter with open forepart shoe. These shoe collections can increase design preference of target user.

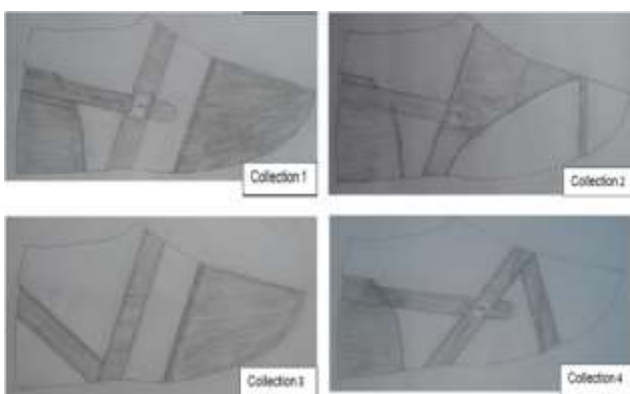


Fig. 2. All shoe collections design pattern

### **Upper parts preparation and closing**

Preparation is a series of operations in preparing shoe parts for the ultimate stitching. The upper parts are prepared from cow hide and white synthetic leather is folded on the upper edge for better aesthetic appearance.

### **Outsole designing**

The researcher masked the bottom profile of 42 size last using crepe adhesive tape (Scotch tape) and removed excess adhesive tape around feather edge of last. The crepe adhesive tape is removed from bottom profile of last and pasted on pattern sheet. To get the out sole, 5mm allowance is added on full edge of pasted bottom profile of last.

### **Tire outsole preparation**

The researcher used rampi and cutter to prepare tire sole based on prepared sole design (Fig. 3).



Fig. 3. Prepared tyre outsole

### **Cows hide upper and tyre sole attachment techniques**

Lasting is the process of stretching upper material over the last and securing it to the bottom of the insole either with tacks, adhesives or threads. Construction is the method of attachment of sole with the upper. There are different methods of shoe construction such as cemented, Blake stitched, Bologna, Goodyear welted, direct injection molding etc. Cemented construction is the most simple and cheap construction method where the parts of the shoe are simply glued together with strong adhesive. Blake stitched construction is sewn construction methods, which is first glued with adhesive and seam is used for extra strength. Bologna construction quite similar to the Blake stitched construction with a seam that runs right through from the outsole to the insole. In Goodyear welted construction a canvas rib is glued to the underside of the insole to which upper and thin leather strip is attached, called welt, with a machine stitched welt seam. The outsole is then attached to the welt with a sole stitch. Direct injection molding is a process where the sole is moulded directly onto the lasted upper. The researcher selected Blake stitched construction for upper and sole attachment, because it is easy,

cheap and adhesive and extra seam used will provide better strength.

**New shoe collections assembling (Shoe Lasting)**

The researcher used manual lasting method and used different manual lasting tools like pincer, rampi, tacks, nail lifter or tack puller, scissors and 42 sizes last. The upper parts are is stretched over the last securing it to the bottom of the insole using tacks and the stretched uppers are stored for 24 h in order to retain last shape. Where, Tacks are removed from the lasts and adhesive is applied on both upper and insole part on lasting margin and after 15 min drying time of adhesive, the uppers and insoles are attached together. Rampi tool is used to remove excess accumulation of lasted upper from the lasting margin. The researcher selected Blake stitched construction for upper and outsole attachment. Adhesive is applied on both upper and outsole, it dries for 15 min. Stove heat is used to reactivate the adhesive and out sole is attached with upper. As can be seen in fig. 4, the lasted uppers are stored for 4 hours at room temperature to retain last shape. Finally the shoes are de-lasting and the

shoes upper and outsole are stitched manually using sewing thread for better attachment of upper and outsole.








Fig. 4. Developed new shoe collections

**Results and discussion**

**Cost comparison**

As shown in Table 1, the researcher new shoe collections are compared with locally available tyre sandal shoes and traditional sandal shoes. The maximum selling cost of new shoe collection which is 2.74\$ has a 0.89\$ difference with local tyre sandal shoe selling cost which is 1.85\$.

Table 1. New shoe collections cost comparison with currently available sandal shoe in Bahir Dar area





S.No.	New shoe collections or models	Local Traditional shoe around Bahir Dar city	Local Tire and plastic sandal shoe around Bahir Dar city
1	Collection 1: Production cost (PC) = 1.62\$ Profit: 70% of production cost Selling cost = 2.74\$	Traditional shoe: 1 Selling cost = 4.44\$ 	Local tire sandal shoe selling cost = 1.85\$ 
2	Collection 2: Production cost = 1.52\$ Profit: 70% of production cost Selling cost = 2.66\$	Traditional shoe: 2 Selling cost = 2.96\$ 	Plastic sandal shoe Selling cost = 2.4\$. Birr- 
3	Collection 3: Production cost = 1.23\$ Profit: 70% of production cost Selling cost = 2.11\$	Traditional shoe: 3 Selling cost = 2.22\$ 	---
4	Collection 4: Production cost = 1.23\$ Profit: 60% of production cost Selling cost = 2.11\$	---	---

This indicated that tire sandal shoe is cheaper than first shoe collection, but first shoe collection has additional features that reduce foot crack related problem and gives additional values like comfort and aesthetic appearance. The minimum selling cost of new shoe collection which is 2.11\$ Birr has a 0.26\$ difference with local tire sandal shoe. This indicated that their difference small. Traditional sandal shoes which are produced around in Bahir Dar city have three different sandal designs. The maximum selling cost of new shoe collection which is 2.74\$ has a 1.7\$ difference with first design traditional sandal shoe selling cost which is 4.44\$. These indicated that new shoe collection is cheaper.

*Fitting test and target group response*

The minimum selling cost of new shoe collection which is 2.11\$ has a 0.11\$ difference with third design traditional sandal shoe selling cost which is 2.22\$. This indicated that they are relatively similar. A plastic sandal shoe which is sold around Bahir Dar city has opened strap at toe cap and closed at heel area is sold in 2.4\$. The maximum selling cost of new shoe collection which is 2.74\$ has a 0.34\$ difference and the minimum selling cost of new shoe collection which is 2.11\$ has 0.29\$ difference with plastic sandal shoe selling cost which is 2.4\$. This indicated that their cost relatively similar and added values on new shoe collection will maintain their difference.

Table 2. Fitting test and target group response to new shoe collections

S. No.	New shoe collections	Target group response	New shoe collections Fitting Test by Target group farmers
1	Shoe collection 1	Good fitting and heel grip. Keep foot toe and heel part from foot crack related problem and dirt. Better aesthetic appearance. Good upper and sole attachment. Light weight than tire sandal.	
2	Shoe collection 2	Keep foot toe and heel part from foot crack and good heel grip. Better appearance. Better upper and sole attachment. Light weight than tire sandal.	
3	Shoe collection 3	Keep foot toe part from foot crack and dirt. Best fitting Better appearance. Better upper and sole attachment. Light weight than tire sandal.	
4	Shoe collection 4	Best fitting and good heel grip. Keep foot toe and heel part from foot crack and dirt. Better appearance and cute style. Better upper and sole attachment. Light weight than tire sandal.	

Fitting Test and Target group response shown in Table 2 showed that, new shoe collection has good aesthetic appearance than tyre sandal and collection 1, 2, 4 has good heel grip made from leather trims. The tyre sandal produced around Bahir Dar area is single design with having only strap on the top but, the new shoe collections can increase users design

preference and keep their feet from foot crack related problem and dirt.

*Sandal shoe comparison*

The table 3 shows the interaction and difference of new shoe collections, tyre sandal and traditional local sandal. These shoes have difference on material type, design and method

of shoe construction. While selecting a raw material, the researcher focused on compatibility of material with the foot, durability during end use and cost. In designing and development of appropriate tyre shoe the researcher also focused on customer preference, aesthetic appearance and fitting. The selected method of shoe construction has a vital role for durability and fitting of new shoe collections. The upper material used to produce new shoe collections and traditional local sandal is raw hide. Raw hide is breathable, flexible, easily cut and joined by thread seam. The sole material used to produce

new shoe collections and tyre sandal is tyre sole. Tyre is a durable and abrasion resistant material. New shoe collections have better advantage than other type of tyre sandal, plastic sandal and Traditional sandal shoe. New shoe collections are made from foot compatible upper, strong and durable tyre sole and strong upper and outsole attachment is used. The researcher new shoe collections can reduce foot crack problem and fulfill target group requirement. During Target group field test willingness of target group to use all new shoe collection is observed.

Table 3. New shoe collections comparison with currently available sandal shoe

New shoe collections	Tyre sandal	Traditional local sandal
Reduce risk of having foot crack problem.	It will cause foot crack problem.	It will cause foot crack problem.
Light weight (300-400 g).	Heavy in weight (500-600 g).	Light weight.
Better upper and outsole attachment.	Poor upper and outsole nail attachment.	Uses poor quality adhesive for upper and sole attachment.
Cheap and strong recycled outsole.	Cheap and strong recycled outsole.	Lesser plastic outsole strength than tyre sole.
Attractive design.	Design is not attractive.	Attractive design.
Multi design possibility.	Limited design possibility.	Multi design possibility.
Breathable and Flexible upper.	Cheaper than other shoe type.	
Better fitting.	Easy to make.	
Eco-friendly upper.	Hard tyre strap.	

## Conclusions

Different shoe collection made on the study can reduce footwear related problem due to local tyre sandal, can enhance target group design preference and can enhance tyre sandal producers creativity. Currently tyre sandal producers in the area following traditional way manual shoe making. They can measure customers' foot size manually by tracing their foot on the tyre surface without standard last and they don't have any knowledge related to standard shoe making. They use nails or tacks for tyre strap and tyre outsole attachment, which has a disadvantage on users feet. In order to overcome this problem, it is required to train the producers on modern shoe making. Bahir Dar Poly technical College and Ethiopian Institute of Textile and Fashion Technology in the area need to give training on standard shoe making for tyre sandal producers in the area. In the target area, there is lack of research work have been done before related to tyre sandal and further studies are required to increase the value of waste tyre and raw hide for footwear and related products.

## Conflicts of interest

The author declares there is no conflict of interest.

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