Evaluation of Sustainability & Materials Among Major Footwear Brands

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Abstract

The waste generated from the footwear industry starts from the beginning of the design and creation of shoes. Global demand for footwear has increased throughout the decades. Up to 40 diverse types of materials are used to manufacture footwear, which can take many years to decompose. Many footwear brands are analyzing how they are creating their footwear and finding solutions to reduce their environmental impact. Sustainability efforts from major footwear brands have started to consider designing for longevity, as well as recycling waste and using biomaterials that will disintegrate faster. This study describes sustainability efforts of two major footwear brands with a focus on their use of materials with a content analysis. Among Nike and Adidas, ten footwear items available online were identified as sustainable during Spring 2022. For Nike, it was common for at least 20% of materials to be recycled by weight. The upper and midsole of this footwear were commonly referred to. Prominent features for comfort included the overall design, materials, and cushioning. For Adidas, it was common for footwear to be made of at least 75% Prime blue yarn and have at least 50% of the upper made of recycled materials. The laces and upper of the footwear were commonly referred to. Prominent features for comfort included the materials used. Other major footwear brands were also considered but did not have as many sustainability options. Second-hand footwear of major brands was also deconstructed to observe materials. This research can contribute to sustainable footwear materials research and be helpful to students and practitioners.

Keywords: footwear, sustainability, design, materials, business
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Epigraph

We can just consume our way to a more sustainable world.

-Jennifer Nini, Top eco influencer and SOL Organics ambassador

Introduction

Global consumption of footwear has doubled every 20 years since the 1950’s. It is estimated that in 1950, each person in the world consumed one new pair of shoes per year; in 2005, over 20 billion shoes were consumed (Mwinyihija, 2018; Rahimifard et al., 2007). To meet global footwear demands, production reached $24.2 billion, which is about $74 per person in the US. This equates to three new pairs of shoes for every individual across the globe (Portuguese Shoes, 2019). This marks a rapid change in footwear consumption over the decades.

With greater consumption of footwear, it is critical to evaluate environmental concerns. One sneaker can take up to 40 years to decompose in a landfill and it is estimated that over 300 million pairs of sneakers are thrown away annually (Ismael, 2021). Environmental concerns persist in the production of raw materials and during the footwear manufacturing process. This includes the use of hazardous materials and chemicals in footwear, air, and water pollution, as well as solid waste generated during the production process (Van Rensburg et al., 2020). In particular, the use of chromium as a tanning agent for leather is highly toxic and a suspected carcinogen, which is a major environmental concern for the footwear industry. However, the most important environmental challenge that the footwear industry currently faces is the enormous amount of waste generated at the end-of-life phase, with most shoes being disposed of in landfills. Landfill sites can result in serious environmental pollution of groundwater and
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rivers, caused by landfill leachate—the liquid produced from the decomposition of waste within the landfill (Staikos & Rahimifard, 2007).

With the fast-paced growth of the footwear industry and the great environmental impact that it is creating, we must create more sustainable products to protect and conserve our planet for future generations. Our biggest impact on the environment from the footwear industry comes from the materials that are used in the creation of footwear in the first place (Shoe Industry, 2007). There is not a specific product that is 100% sustainable, but we can reduce material waste by selecting ideal materials. By selecting the right source, location, vendor, and material type we can create more sustainable shoes. There is so much more exploration in circularity and sustainability and how we can do better things in a more efficient way. Environmental sustainability is by definition; “taking a resource and maintaining its use without causing permanent damage.” Simply put, a linear lifecycle is not sustainable. Circularity offers a more sustainable solution where designs do not become waste and products are kept in use (Ellen MacArthur Foundation, 2021).

Research Purpose

The purpose of this research is to evaluate major footwear brands based on their sustainability efforts with materials and to source footwear from major footwear brands for deconstruction and material analysis. A content analysis of major footwear brand websites was conducted to evaluate their sustainability efforts. The aim of this paper is to address a research gap regarding sustainable footwear by obtaining a better understanding of existing materials that are used in the footwear industry to reduce environmental impacts.
Literature Review

Footwear Market

The global per capita consumption of footwear has also considerably increased, from one pair of shoes for every person in the world in 1950 to almost 2.6 pairs of shoes in 2005 (Lee & Rahimifard, 2012). However, footwear consumption differs significantly between countries. Although China, owing to its large population, has the highest footwear consumption in the world, the US is the country with the highest per capita shoe consumption, since each inhabitant buys an average of 6.9 pairs of shoes every year (Worthington, 2022). In Europe, and in the case of the 25 member states of the European Union (including the new member states), the yearly per capita shoe consumption in 2003 was 4.5 pairs of shoes, while in the United Kingdom the average was slightly higher at 5.3 pairs. At the other extreme, in the less developed countries, the per capita shoe consumption is 0.6 pairs for India and 0.5 pairs of shoes for Vietnam (all types of shoes included) (Hackenmiller-Paradis, 2019).

In the article The Science of Footwear, it supplies an in-depth understanding of the technology and techniques involved in the design and development of a popular and demanding consumer product (Goonetilleke, 2012). Knowledge of science and design in footwear will help to make informed decisions about choosing alternative materials that are less harmful to the environment and achieve the same or better aesthetics and features as those materials that are been used already and end up in landfills contaminating the environment. The Footwear Distributors and Retailers of America (FDRA) defines shoe sustainability as “shoe design, development, manufacturing, distribution, and selling processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees,
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communities and consumers, and are economically sound” (Deckers, 2021). This powerful combination will allow the creation of products that can be part of a circular economy in which everything that reaches its end-of-life stage can return to the environment with no or less harm to it.

Current Footwear Materials

Footwear products are mostly made of leather, textile, and a range of synthetic materials (Smith, 2022). For manufacturing shoes, several types of materials are used. There are approximately 40 different materials used in the manufacturing of shoes. However, the common material composition of a typical shoe is leather 25%, polyurethane 17%, thermoplastic rubber 16%, ethylene vinyl acetate 14%, poly vinyl chloride 8%, rubber 7%, another 7%, textiles and fabrics 6% (Ahmad et al., 2017). Solvent-based- vapor cements may form explosive mixtures with air, including toxic gases/vapors/fumes of: Carbon dioxide (CO2). (Safety Data Sheet the Free Solvent, 2006).

Common materials in footwear were chosen based on their low cost combined with their ability of easy and fast manufacturing. According to the Better Shoes Foundation (2021), shoe uppers are commonly made of chrome tanned leather, conventional (non-organic) cotton, basic (cationic) dyes, acid dyes, disperse dyes, vat dyes, direct (substantive dyes), durable water repellent (DWR) treated fabrics, PVC (polyvinyl chloride). Materials most used in soles are chrome-tanned leather, PVC (polyvinyl chloride), PU, TPU (thermoplastic polyurethane), EVA foam (ethylene vinyl acetate), petroleum rubber, and illegally logged wood. Materials used for heels are ABS (Acrylonitrile Butadiene Styrene). Methods used to join parts are solvent-based adhesives (Sven, 2021).
Creating shoes requires textile materials, leather, plastic, and rubber parts glued and sewn together that are not environmentally sustainable (Motawi, 2018). How shoes are currently made makes them difficult to recycle. The use of polyurethane cement to glue and stitch upper parts and outsoles makes it almost impossible in financial terms to break down a shoe and use its components again. On the other hand, the construction of shoes consumes substantial amounts of water and energy, and in the process leaves enormous quantities of post-industrial and post-consumer waste. To be able to lessen the negative environmental and social impacts of shoe production footwear designers, shoe developers, product managers, and factories can make more sustainable decisions. Important choices they need to consider are material selection, sustainable footwear production processes, and waste reduction in footwear manufacturing (Motawi, 2018).

PVC is the third most widely produced synthetic polymer of plastic (after polyethylene and polypropylene). About 40 million tons of PVC are produced each year (Basmage & Hashmi, 2020); it has dangerous chemical additives including phthalates, lead, cadmium, and/or organotins, with additives that can leach out or evaporate into the air over time and are toxic to people (State of New Jersey, 2008).

**Sustainability and Footwear**

There are limited studies regarding sustainability and footwear. A case study by Hale and Baker Jones (2021) explored footwear brand sustainability goals and the role of product developers to enact best practices based on the selection of materials. Based on concerns with leather, the Leather Working Group provided guidance for leather with a reduced environmental impact. Initiatives with recycled polyester are also being implemented for footwear uppers. Primary challenges with recycled materials such as plastics and rubbers include quality and durability issues. The secondary sneaker market is also becoming more prominent based on
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Consumer interest in sustainability. A consumer study with Millennials and Gen Z consumers found that reducing risks to consumers and supplying information is important to improve their attitudes towards resale retailers and purchase intentions (Slaton & Pookulangara, 2021).

“Sustainability is not something that happens at a single point in the process. It involves the manner in which the raw materials are sourced, how they are transported, and the process of manufacturing. Added to this, it looks at where the shoes go when they are no longer useful” (Zero Waste, 2022). Therefore, the concept of circular design emerged. Circular design means thinking about the product end-to-end and all the lives that the product can have. From the beginning of the process, designers need to think about what materials to choose and try to use recycled materials as much as possible. Designers also need to think about waste from the first stage of creating footwear, they might use fewer materials or pattern the material in a way to reduce the waste. Designers must also consider when an athlete is finished with their product, whether there are opportunities to return it to the company they bought it from to reuse its components and then turn it into a new product to give it multiple lives (Gorgensen, 2019).

New scientific technologies have allowed the creation of sustainable materials that are bio-based; therefore, they can disintegrate easier and return to nature, while also reducing waste (Moshood et al., 2022). The following presents alternative sustainable materials to commonly used materials for shoes. For uppers, it is common to use leather; however, alternatives have been developed for example Appleskin, BeLeaf™, BioVeg, Biocouture, Cellulosic Fiber, Cactus Leather, Cork Sheeting, Fine Mycellium, Fruitleather, Grape/wine leather, Mirum™, Modern Meadow, MuSkin, Mylo™, Piñatex™. Chrome tanned leather (a.k.a. wet blue) the tanning agent that is suspected to be carcinogenic can be replaced by Vegetable tanned leather, Rhubarb leather®, wet-green®. Suede/nubuck can be replaced by Ultrasuede®, Dinamica®. Non-organic
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cotton can be replaced by bast fibers. Polyester-based fabrics can be replaced by Biosteel, Climatex, or Thread International. Conventional dyes can be replaced by low-impact reactive dyes, DyeCoo. PFC-free membranes can be replaced by Sympatex. PFC (Poly Fluorinated Chemicals) finishes can be replaced by Bionic-Finish®Eco, Nikwax.

Major Brands

Adidas

Adidas AG is the largest sportswear manufacturer in Europe and is second only to Nike worldwide. Adidas is a multinational corporation, founded and headquartered in Herzogenaurach, Germany, which designs and manufactures footwear, apparel, and accessories (Tighe, 2022). The Adidas group is made up of Reebok, TaylorMade, and Runtastic. The company also owns a share of the German football club Bayern Munich. Adidas' logo is three stripes, which is used on the company's apparel and footwear designs as marketing. Some of Adidas' major competitors are Nike, Puma, and Under Armour. As of 2020, Adidas will be the third largest apparel brand in the world, with a brand value of $16.5 billion (about $51 per person in the US) US dollars. The company is also one of the most valuable athletic apparel, accessories, and footwear companies in the world. Over the years, the Adidas brand surpassed Nike and other global athletic footwear brands among US consumers, based on a ranking of customer satisfaction levels (Tighe, 2022). Most recently, Adidas fell closely behind Nike in terms of customer satisfaction, achieving a score of 77 out of 100. The company will employ approximately 62 thousand people worldwide in 2020. The Adidas Group's global net sales amounted to about $20.99 billion dollars in 2020, signifying a decrease compared to the prior year due to the coronavirus (COVID-19) pandemic. In 2020, the North American region of the Adidas Group generated 24 percent of the company's retail net sales. Footwear and apparel are
two of Adidas Group's biggest segments. In 2020, the company produced 448 million pairs of shoes worldwide and 379 million units of sports apparel (Tighe, 2022).

**Sustainability.** Adidas' sustainability efforts started in 1998 when the company announced its environmental and social standards that all its suppliers must uphold (Koopman, 2016). In 2012, Adidas equipped all volunteers at the London Olympic Games with uniforms made from recycled polyester. Three years later Adidas partnered with the environmental organization “Parley for the Oceans” and created a shoe that uses Parley Ocean Plastic as an eco-innovative replacement for virgin plastic. They made an appearance together at the United Nations as part of a long-term eco-innovation partnership (Adidas, 2022).

By 2021, more than 70% of the polyester Adidas used in products will be recycled. Part of Adidas' goals by 2024 is to eliminate the use of virgin polyester wherever possible. Adidas is committed to making use of sustainable technology, sustainable materials, design, and manufacturing methods in 9 out of 10 Adidas products. By 2025, Adidas' goal is to achieve carbon neutrality across its entire supply chain. Adidas plans to create change by innovating in the use of materials in their products; they want to use products that can be either recycled or remade and returned to nature in a regenerative loop (Port, 2021). This will allow them to more fully contribute to a circular economy (Adidas, 2022).

Adidas (2022) examined the environmental impact of the materials they are using and shared their use of sustainable materials: “The most used sustainable materials we use are “Better Cotton, recycled polyester, recycled nylon, recycled rubber, algae-based EVA, TENCEL, water-based polyurethane (PU), and recycled thermoplastic polyurethane (TPU).” Adidas is a member of the Leather Working Group (LWG), this means that hides used by the brand come from tanneries that have leather traceability with slaughterhouses, including the date. LWG ensures
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that all suppliers show proof of traceability of their raw materials and accordingly follow compliance with all stated regulations. Adidas always ensures that its suppliers work with tanneries that only source their raw materials from LWG Gold-rated members, ensuring their operations are not involved with deforestation (Adidas, 2022).

**Nike**

Nike, Inc. (2022) is an American multinational company engaged in the design, development, manufacture, and marketing of footwear, apparel, equipment, accessories, and other sporting goods. It is one of the world's largest suppliers of athletic footwear and apparel, and a major manufacturer of sports equipment with revenues of more than US $24.1 billion (about $74 per person in the US) and a workforce of approximately 44,000 employees (about twice the seating capacity of Madison Square Garden) worldwide in 2012. The brand alone is worth US $10.7 billion (about $33 per person in the US), making it the most valuable brand among sports corporations. The company was founded on January 20, 1964, as Blue Ribbon Sports by Bill J. Bowerman and Philip H. Knight, and officially became Nike, Inc. on May 30, 1971. Nike markets its products under its own brand name, as well as under Nike Golf, Nike Pro, Nike +, Air Jordan, Nike Skateboarding, Hurley International, and Converse, among others. In addition to sportswear and equipment manufacturing, the company owns Niketown stores. Nike is a sponsor of many high-level athletes and sports teams around the world, with the famous slogan "Just do it." The Swoosh logo was created by Carolyn Davidson and outlines a wing of the goddess that gives the brand its name (Companies History, 2020).

In 1992 Nike published its mission, values, and principles statements with standards of professional conduct, the list of its suppliers and factories they work with, worker compensation,
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and overtime work disclosures as well as a declaration of no tolerance for forced labor and care for the health safety of their workers (Nike, 2022).

**Sustainability.** Nike’s vision is about becoming a company that contributes to a circular economy. By “creating products that last longer and that are designed with the end in mind” (Nike, 2022). They have 10 main principles for circular design. These all include choosing materials that have a lower environmental impact. Taking into consideration the cyclability of the product and how the product will be recycled at the end of use. By rethinking a new method of making the products, Nike also aims to reduce waste at the time of shoe construction.

Designers must think about the disassembly of the shoe once the shoe is returned, considering using adhesives that are more environmentally friendly. In addition, refurbishing shoes to extend their life, versatility, and durability of the footwear. And finally, the constant creation of new models that use these principles and come up as an ethical product that will be better for the environment (Nike, n.d.). Nike recently launched the “Move to Zero” initiative to counteract climate change (Cook, 2020). The program prioritizes carbon waste and aims to get to zero carbon. Carbon is the leading contributor to climate change. We want to use recycled materials as often, and use zero carbon materials (On-Running, 2022).

To supply additional context, Nike has a strong history of sustainability efforts. In 1995, Nike reduced the use of solvents by 95% to avoid exposing workers to harmful fumes, by switching from petroleum-derived solvents (PDS) to wastewater-based adhesives. Starting in 1997, Nike committed to phase out the use of all SF6 F-gases, a gas used in cushioning air soles that contributes to global warming. By 2006, Nike completely ceased the use of these gases. In 1998, Nike adopted US OSHA (Occupational Safety and Health Administration) clean air
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standards to improve the environment for workers. In the same year, the company ended the use of Polyvinyl Chloride (PVC) (Nike, n.d.).

In 2002, Nike developed an environmentally friendly rubber for footwear outsoles that has 96% fewer toxins by weight than the materials they were previously using. It's in 2006 when the company started to instill education on the best selection of materials from the beginning of the design process of shoes, they wanted to start promoting the creation of shoes by thinking about the waste that will be generated and how the materials will disintegrate back into nature. In 2008, Nike launched the Air Jordan XX3, they created the shoe by using innovative technology that employs a water-based bonding process that allows the carbon fiber cement plate to be attached without the use of solvent-based cement (Gunther, 2008). Another sustainability initiative from the company was that they used the waste from the factory floor and integrated it into various parts of the shoes such as uppers, midsoles, and outsoles. In 2010, Nike introduced environmentally friendly jerseys, for the national teams playing in South Africa including Brazil, Portugal and Netherlands. These jerseys were made entirely from recycled polyester, each made from up to eight plastic bottles (Niskanen, 2019).

An example of Nike taking sustainability to scale is with the Vapor Max 2020 shoe. The Nike air sole units are created in a facility that runs on 100% renewable energy. When forming the air soles any scrap that is left over is integrated into a new material. Every time you see an air sole you have at least 50% recycled content in it. The way they created Vapor Max 2020 has 70% recycled content in it. On the upper sole, it has Flyknit, which is a platform made of a polyester thread (Daniels, 2018).
Content Analysis of Major Footwear Brands

Content analysis is a technique used in many fields of study. Content analysis is applied as a collection tool when there is quantitative or qualitative data in research. The main goal in content analysis is to study and analyze information in a systematic, quantitative, and objective manner (Daniels, 2018). In this research, we are going to make inferences objectively and systematically from analyzing the Nike and Adidas online website descriptions for their sustainable shoes. As well we will organize the qualitative data into fewer content categories, this will allow us to describe the focus of the content on each website from these major footwear brands and therefore make inferences about the brand's main approach to the consumer through their product description (Daniels, 2018).

In this study, we identified top brands that may integrate sustainability – (Nike, Adidas, New Balance, Puma). Then identified 10 footwear on the websites from Nike and Adidas as these had 10 footwear that was marketed as sustainable.

Footwear Deconstruction

Second-hand footwear was sourced during Spring 2022 for dissection and material observations.

Sourced from eBay, the cost was between $19 to $30. The following were the footwear sourced:

- Nike Zoom Pegasus 31 Violet Black Running Shoes Youth 7Y
- Adidas NMD R2 Prime knit PK Men's 8 White Core Gray Running Jogging
- Black Puma Nrgy Neko Engineer Knit Fitness Running Shoes

The footwear was washed in a home laundry machine. The wash settings were medium, wash hot, light cycle, and extra rinse. The dry settings were cotton dry for 30 minutes. The footwear
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was cut in half for observations based on examples shown in Ch. 27 of Motawi (2017).

Shoelaces were removed, uppers were cut with scissors, and midsole and outsoles were cut with a utility knife.

Results

Content Analysis

This study conducts qualitative research of content by observation. The result of this study finds that in a sample size of 10 taken from Nike’s online website 80% of the labeled shoes as sustainable, are made of at least 20% recycled material by weight. Whereas in a sample of the same size taken from Adidas online website 30% of the labeled shoes as sustainable, are made of at least 75% Prime Blue Yarn in their textiles and 90% from the sample, their uppers are mainly made of at least 50% recycled materials made in part with Parley Ocean Plastic. In the study, a sample of size 10 is taken from Nike and Adidas websites to analyze the content description. Nike content description a 90% from the sample describes the overall design of the shoe, followed by a 60% description of their use of materials, 50% describes its cushioning, and a 20% the shoe performance. Whereas Adidas content analysis from a sample of size of 10 taken from its website, 70% of the content describes materials and cushioning of the shoe, followed by a 60% description of the overall design and finally a 20% description of the shoe overall performance. The materials description of the shoe has also been analyzed and found that Nike shoes describe its materials in 80% its midsole, followed by a 70% it's upper, then 50% talks about the sole description and finally, 10% describes the shoelaces. Adidas shoe description is more balanced by describing in a more uniform manner the shoe materials, in its content description it mainly describes the shoe upper in a 90%, then an 80% the midsole and laces, and finally a 70% of content description of the sole. Other brands were considered for this research
but there was not enough information for analysis since their sustainability initiatives are mainly in progress.

**Footwear Deconstruction Observations.** From the deconstruction, I found that the footwear materials are common materials mentioned in the literature (Motawi, 2018). The observations shown in Figures 1 through 6 are subjective and open to further interpretation.

**Figure 1**  
*Second-hand Nike footwear as a whole and cut it in half*

![Figure 1](image1)

**Figure 2**  
*Analysis of second-hand Nike footwear as a whole and cut it in half*

![Figure 2](image2)
Figure 3
Second-hand Adidas footwear as a whole and cut it in half

Figure 4
Analysis of second-hand Adidas footwear as a whole and cut it in half

Figure 5
Second-hand Puma footwear as a whole and cut it in half
Conclusions

From this study, we can see that Nike uses less quantity of sustainable materials in their shoes, but it incorporates them in more styles versus Adidas that uses a larger quantity of recycled materials, but in fewer styles. This research will serve to examine current efforts and developments occurring in footwear materials of major footwear brands. It highlights the urgent necessity to apply and develop solutions to reduce textile waste generated from the footwear industry.

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