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Eco-Friendly Cinematic Practices: The Sustainable Use of Film Costumes

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Abstract
The film industry is a powerful medium for cultural storytelling and entertainment, yet it is associated with significant environmental challenges. Among these, the lifecycle of movie costumes—from design and production to disposal—remains a critical yet underexplored area. Costumes often involve resource-intensive processes and generate substantial waste. This paper examines the method for sustainable practices in the design, production, and reuse of movie costumes, highlighting strategies such as upcycling, rental systems, the adoption of eco-friendly materials, and the integration of digital technologies. By embedding circular economy principles into costume production, the industry can balance creativity with environmental responsibility, showcasing a blueprint for eco-conscious filmmaking.

Keywords: *Movie Costumes; Characterization; Carbon Footprints; Sustainability; Waste Reduction, Setbacks; Responsible Film Making.*

1. Introduction
Movie costumes enhance cinematic narratives, helping audiences connect with characters and settings. Movie costumes are not just about clothing; they are an essential tool in storytelling. They play a pivotal role in filmmaking, not only enhancing the visual appeal of a film but also contributing to the enhancement of narration, development of characters, themes, and storylines, through thoughtful design within the film. The design and selection of costumes are integral to creating a believable world for the audience, helping to establish the period, setting, and emotional tone. They can also serve as a tool for expressing character traits, symbolism, and cultural context. Costume designers play a crucial role in helping a film feel immersive, authentic, and emotionally resonant, making their work an indispensable part of the filmmaking process through the dresses. However, traditional costume design and production often rely on environmentally harmful practices. The use of common methods, fabrics, excessive energy consumption, and a "single-use" mindset contribute to the film industry's ecological footprint. As the demand for sustainable filmmaking grows, the industry must address the challenges associated with costume production. These practices align with the industry towards "Green Filmmaking". The paper will sightsee the current state of use of movie costumes, and need of sustainability, emerging innovations, and pathways for integrating eco-friendly practices in making movie costumes [1-4].

2. Role of Movie Costumes
Movie costumes are the garments and accessories that performers wear to express their roles in a film and were utilized to promote the dramatic effects of the film. This clothing is a significant component of artistic expression in the film; thus, it must be easy for the viewer to understand. The principal characters' clothing are an important aspect of stage and film arts. Their function is not only ornamental, but it also reflects the characters' personalities, cultural and historical backgrounds [5-9]. Furthermore, performers' clothes influence the audience's perception of the play or film, generates a certain mood, and compliments the characters' looks. According to K.Y. Lee and H. Lee (2019), the aesthetic significance of function of costumes in films is related to their ability to reflect cultural and historical contexts and reflect the development of fashion and style throughout different eras. Movie costumes are part of a symbolic language within the medium that delivers meanings of clothing in history and culture and expresses each actor/actress' role in a movie (Hayward, 1997). Movie costumes and make-

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up are sort of visual language and contribute to enhancing understanding of movies by expressing time period, seasons, local color, and personalities, individualities, appearance, disposition, psychology and intention of characters (K. Lee, 2004), so they need to be planned and performed very delicately. Charles Eckert (1978) argued that the pattern and pace of the modern consumer were shaped by movies, film costume continues to shape fashion and consumption via images of desire and through product tie-ins. Costumes are critical in conveying all of the meanings involved with the events and consequences in movies. The audience vicariously gains a sense of satisfaction by accepting and internalizing the costumes seen in the movie and may create or participate in a new fashion trend by adopting the costumes or forms of dress similar to clothes seen in the movie (Hayward, 1997). J. Groot (2008) appraises that the costume as one of the elements of a theatrical production that reflects the aesthetic, historical, and social aspects of the era in which it was created. He also states that there is a huge development of the theatrical costume from ancient times to the present day, as well as its functions and its significance in different cultures, including historical, realistic, symbolic, and fantastical, with influence of technology and fashion on their creation. D. Chatterjee and C. Vasek (2020) described that even theatre actors' costumes perform. According to them, it helps the actors more authentically portray their roles, convey a sense of time and place, and create a certain emotional atmosphere. It was established that the proper use of costumes can increase the level of expressiveness and emotional saturation of a performance or film and improve the understanding of the artistic image, historical era, and mood of the work by the audience, Bezruchko, O., Gavran, I., et. al (2024). The role of costumes in the film industry and it influences on the creation of character images in the movies work. Specifically, costumes can help recreate the time and place of events, Smith, R. (2011). They are an important component of the visual atmosphere that directors want to convey, allowing audiences to be transported to another era or country, says I. W. Budiarsa's (2021) [10-14].

2.1. Costumes to Differentiate Character

The meticulous design and execution of costumes serves as a vital conduit through which performers convey their identities and emotions, fundamentally shaping audience perceptions. Costumes enhance the narrative by visually representing a character's background, status, and personality traits, thereby deepening the audience's connection to the story. For instance, the history of professional theatre beading reveals an intricate relationship between costume design and character portrayal, often overlooked but contribute richly to the visual storytelling, encapsulating the glamour and historical significance of the characters depicted on stage (Alexander et al., 2014). The influence of iconic film stars during this new era illustrates how costumes were deliberately crafted to align with and amplify the established personas of these individuals, further engaging viewers and reinforcing character authenticity (Singpatanakul et al., 2020) [15-18]. According to K .Y. Lee and H. Lee (2019), the aesthetic significance of function of costumes used is to create distinctive characters and style icons that become part of shared cultural heritage and also agrees that the characters' clothing helps viewers better understand their personalities and emotions and can be used to create a sense of time and place. Costumes act as visual shorthand for the audience to immediately grasp a character's personality, social status, cultural background, and psychological state. Lorenzo (2014) in "Costume Design and Identity" highlights how costumes can subtly communicate a character's journey or transformation while maintaining narrative coherence. Designers often use detailed sketches and concept art to ensure costumes align with the director's vision (Malinen, 2017). Attar (2023) asserts that costumes are pivotal in storytelling, helping audiences understand time, place, and themes. By incorporating elements like fabric, color, and texture, designers can align costumes with the narrative's emotional tone. Similarly, Yin (2023) explores how costume design enhances film and television storytelling, portraying characters' identities and driving the plot. Rana (2024) examines the interplay of traditional elements and modern sensibilities in Indian theatre,

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demonstrating how costumes reflect cultural ethos and enhance dramatic expression. Xia (2017) discusses the choice of costume colors to evoke cultural symbols and character archetypes, emphasizing their importance in period and mythological dramas. The technical process of costume design involves collaboration between directors, designers, and other production staff. Warner (2018) outlines the intricate steps designers take, from research to execution, ensuring costumes contribute to the overall visual aesthetic. Tools like concept drawings and digital modelling are increasingly used to refine designs and experiment with different styles, suggests (Huang, 2020) [19-24]. The characters' attire become a key element of a promotional campaign, attracting viewers, and contributing to the project's commercial success, describes Bezruchko, O., et.al (2024). Additionally, actors' attire can reflect their characters' personality, social status, values, mood, and other important aspects of their character. If the costumes worn by movie characters were complement and emphasize the film's plot, they can become an attractive element for the viewer, which influence towards fashion, (Lehenkyi & Arefieva, 2022). Actors and actresses wear the costumes suitable for situations, through which they express not only status and personalities of the characters that they play, but also the relations between characters along with their exterior emotion (J. Kim, 2011). Thus, the movie costume is an important factor that enhances artistic value by expressing characters' psychological function and leads overall story of the movie by functioning as historical and cultural research (S. Kim, 2007). Movie costumes and make-up are sort of visual language and contribute to enhancing understanding of movies by expressing time period, seasons, local color, and personalities, individualities, appearance, disposition, psychology and intention of characters (K. Lee, 2004), so they need to be planned and performed very delicately. Costumes serve as an external manifestation of a character's internal world, for example, in The Devil Wears Prada (2006), the transformation of Andy Sachs's wardrobe mirrors her evolution from an unpolished newcomer to a confident and fashion-savvy individual, reflecting her journey and personal growth. Period films, such as Downton Abbey (2019), rely heavily on costumes to anchor characters in a specific time and place. The meticulous attention to period-appropriate attire not only grounds the narrative in authenticity but also differentiates characters by their socioeconomic status and roles within society. Costumes often underscore themes and narrative arcs [25-29]. In the Hunger Games (2012), the extravagant outfits of the Capitol citizens contrast starkly with the plain, utilitarian clothing of District 12, highlighting societal disparities and political commentary. Costumes can signify relationships and hierarchies among characters as like in Black Panther (2018), the distinct attires of each Wakandan tribe underscore their unique identities while collectively contributing to a cohesive cultural tapestry. Colors and textures play a pivotal role in character differentiation like in Joker (2019), the shift to vibrant colors in Arthur Fleck's costume aligns with his transformation into the Joker, symbolizing chaos and liberation. Costume design can challenge or reinforce gender norms and identities, for example Mulan (2020), the duality of Mulan's attire reflects her struggle between societal expectations and her true self, emphasizing her personal and cultural conflict. Costumes are a powerful tool for character differentiation in films, blending artistry and psychology to create memorable and impactful cinematic experiences. By aligning wardrobe choices with narrative intent, filmmakers ensure that costumes serve as an extension of the story, offering audiences a richer understanding of characters and their worlds. D. Skentelbery (2024) explores the role of costumes in distinguishing characters in media, focusing on the transformation of such practices in cosplay. He says that the costumes not only delineate a character's identity but also reflect societal norms and individual interpretation. Though primarily about cosplay, the research provides insights into the symbolic weight of costume design in popular media, including films. Z. Fang & N. Mansor (2024) states the costumes in animated films like Monkey King reflect mythological and cultural roots, while simultaneously differentiating heroic and villainous characters through visual symbolism. A. Malik,

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Page No: 3736-3747

shares the use of costumes create and confuse distinctions between fictional characters and real personas. K. Weolkye & L. Sangwon (2024), says that historical accuracy and stylistic choices in costume helps to delineate characters in films like Napoleon. Character backgrounds and narratives play a critical role in enhancing the depth and authenticity of visual storytelling. Understanding these elements allows costume designers to create attire that not only fits the characters' physical attributes but also reflects their inner journeys and societal contexts. For instance, as noted in the research on costume integration within the character design process, the inclusion of a costume professional can deepen character immersion and enrich the narrative experience (Salomaa et al., 2018). This approach emphasizes that costumes are not mere accessories but pivotal components of character expression, embodying their histories, motivations, and transformations. Similarly, the evolution of superhero narratives illustrates how increasing diversity in representation impacts audience connection; diverse characters like Black Panther not only reflect a broader cultural narrative but also demand a thoughtful consideration of their visual representation in costumes (Bagnall et al., 2017). All these elements underscore the necessity for a nuanced understanding of character backgrounds, ultimately driving more profound storytelling [30-34].

2.2. Materials Used for Constructing Movie Costumes

Costume designers rely on various materials, each chosen for their aesthetic qualities, comfort, and ability to enhance the character. The material commonly used in costume design helps in highlighting the roles, historical evolution, and practical applications in the film industry. Movie costumes serve as visual markers of character identity, period setting, and narrative context. From historically accurate period costumes to futuristic superhero suits, materials play a vital role in achieving desired effects [35-40]. The materials used in movie costumes are selected based on the character's role, setting, and the overall visual concept of the film. When designing costumes for movie characters, depending on the look, functionality, and durability required for the role, a wide range of materials are used, Smith, A (2020). The combination of these materials is done to create visually striking, functional, and believable costumes for the big screen. The selection of materials for making movie costumes is steered by practicality (e.g., flexibility, comfort), aesthetic needs (e.g., texture, sheen), and the thematic requirements of the film. Costume designers rely on a combination of fabrics, foam, plastics, metal, and even high-tech innovations to bring characters to life on the screen. The choice of fabric and construction methods plays a pivotal role in the authenticity and functionality of costumes, particularly in the modern industry. Selecting the right material not only impacts the aesthetic outcome but also influences the performance of characters within immersive environments. For example, as noted in the research on integrating costume knowledge into character design, the properties of fabrics—such as drape, weight, and texture—can significantly alter how a character is perceived, enhancing storytelling and audience experience (Salomaa et al., 2018). Cotton and linen are widely used in period films for their historical accuracy and breathability. For example, costume designer Jacqueline Durran utilized natural fibres in Pride and Prejudice (2005) to achieve authenticity (Durran, 2005). These fabrics are ideal for lightweight garments and are often hand-dyed to match specific tones. Silk and satin are quintessential for luxury and historical costumes, as seen in Marie Antoinette (2006), where Milena Canonero used authentic materials to replicate 18th-century French aristocracy (Canonero, 2006). Velvet, with its rich texture, is often used for royal or opulent characters, such as the costumes in Elizabeth (1998) designed by Alexandra Byrne (Byrne, 1998). Wool provides warmth and texture, making it suitable for medieval or fantasy settings, as seen in The Lord of the Rings trilogy (Walsh et al., 2001). Leather, conversely, adds ruggedness and durability, as employed in Mad Max: Fury Road (2015) for its post-apocalyptic aesthetics (Beavan, 2015). Polyester and nylon are versatile, lightweight, and durable, making them staples for costumes requiring flexibility or frequent use, such as

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Page No: 3736-3747

superhero suits. Alexandra Byrne's work on Thor: Ragnarok (2017) utilized polyester blends for enhanced mobility and visual appeal (Byrne, 2017).
The stretchable materials like Spandex and Elastane revolutionized the superhero genre, providing the snug fit required for iconic suits like Spider-Man's in The Amazing Spider-Man (2012) (Kym Barrett, 2012). Their elasticity allows actors to perform stunts while maintaining the costume's integrity. Nylon which was known for its durability and elasticity, nylon is a key material in modern costumes requiring both strength and flexibility. Costumes for characters like those in The Avengers (2012) and Iron Man (2008) often incorporate nylon or nylon blends, as it allows for ease of movement and high-impact performance in action-heavy scenes. Often used to create futuristic or high-tech looks, PVC and vinyl are materials that provide a sleek, shiny surface. Films like The Matrix (1999) used PVC to create the signature costumes of characters like Neo and Trinity, capturing the digital, high-tech atmosphere of the movie's cyberpunk world. Foam rubber and latex are commonly used to create lightweight, durable costumes, prosthetics, and armour, Miller, J (2019). These materials are flexible and mouldable, allowing costume designers to create large, dramatic pieces like those seen in The Lord of the Rings (2001-2003). For example, the armour worn by the orcs and the elves, as well as the prosthetics for Gollum, relied heavily on latex and foam. Materials like Gelatin and Silicone are used to create realistic prosthetics, such as wounds, scars, and fantasy creatures. Silicone, in particular, is favoured for its skin-like texture and ability to stretch, making it ideal for creating masks and prosthetic pieces. Films like Star Wars (1977) and Hellboy (2004) used these materials extensively to create alien species and fantasy characters. For hard prosthetics and armour, casting materials like plaster and resin are commonly used as they can create sturdy and realistic pieces, such as helmets or skeletal structures, that are essential in creating alien or armoured costumes.

2.3. Sourcing Materials for Making Movie Costumes

The materials used to create costumes are essential for the success of the design process. Givens From the historical accuracy of period costumes to the futuristic allure of science fiction attire, the right materials ensure that costumes not only fit the narrative but also contribute to the overall aesthetic and immersive experience of the film. The sourcing of materials for costumes is a crucial aspect of the costume design process, involving collaboration between designers, fabric suppliers, and other production staff. This process is influenced by a range of factors, including the film's genre, historical setting, character portrayal, budget constraints, and environmental considerations. One of the most common methods of sourcing materials for costumes is through collaboration with fabric suppliers and manufacturers. Designers typically work with suppliers who specialize in a wide variety of fabrics, from common materials like cotton and wool to more specialized ones like silks, velvets, and synthetics. The fabric suppliers provide swatches, and the designer can choose the most suitable ones. In cases of large-scale productions, fabric is often custom-dyed or treated to match the intended color scheme of the costumes. Costume designers often begin by consulting with fabric suppliers to select the appropriate materials that align with the vision of the film. For period pieces, such as The Tudors (2007–2010) or The Favourite (2018), designers sourced period-appropriate fabrics, such as brocade, velvet, and silk, to ensure historical accuracy. In some instances, bulk purchasing is necessary to ensure that there is enough fabric to accommodate a large number of costumes. This is common in historical epics or ensemble films where many characters require similar attire. Suppliers may provide bulk rolls of fabric, which are then tailored into individual costumes. For example, the Lord of the Rings trilogy (2001-2003) involved mass production of various wool and linen fabrics for the vast number of costumes required for the numerous characters. For films with highly specialized or fantastical designs, custom fabrication and crafting of materials may be necessary. This is especially common in genres like fantasy, superhero, or sci-fi films, where costumes are created from scratch or modified to incorporate unique elements such as armour or prosthetics. In films like Avatar (2009) and The Matrix (1999),

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Volume: 02
Issue:12 December 2024
Page No: 3736-3747

custom fabrics and specialty materials were created for costumes that could not be found through regular suppliers. Costume designers may work closely with fabricators who create custom fabrics, including textiles with metallic finishes, holographic elements, or intricate weaving patterns. In films requiring specialized costumes, such as superhero suits or alien outfits, prototypes are often made before the final design is implemented, Pearson. H, (2017). Designers may consult with special-effects teams to create prototype versions of a costume, experimenting with different materials, textures, and finishes before settling on the final look. For example, the Iron Man (2008) and Black Panther (2018) films required extensive prototyping to perfect the high-tech, dynamic looks of the characters' costumes. In some cases, film productions may look beyond local suppliers to source materials globally, Taylor, R. (2018). Different countries and regions have specialized fabrics or manufacturing techniques that may be required for a specific film, especially for historical accuracy or unique design features. For example, films set in specific geographical locations or time periods, designers often look to the countries or regions that produced these materials historically like in films The Last Emperor (1987), traditional Chinese silks were sourced from local artisans in China to ensure authenticity [41-44].

3. What Happens to Movie Costumes After Used

As movie costumes are essential elements of storytelling, enhancing characters and setting the tone of a film, after production wraps, these costumes often have intricate fates. They may be archived, sold, displayed, reused, or discarded, depending on their cultural, financial, or artistic significance. Costumes from landmark films are often preserved in studio archives or museums. These archives are crucial for historical preservation, providing future filmmakers, researchers, and fans access to cinema history. Studios like Warner Bros. and Disney maintain extensive archives where costumes are kept in controlled environments to prevent degradation.

For example, Dorothy's ruby slippers from The Wizard of Oz (1939) are housed in the Smithsonian Institution. Similarly, the Batman suits from various films are stored in Warner Bros.'s archives (Warner Bros. Studio Tour (2023). These preserved costumes often appear in exhibitions, offering fans an opportunity to connect with their favourite films. Movie costumes frequently find their way into auctions, fetching substantial sums from collectors and fans. Iconic outfits, like Marilyn Monroe's white dress from The Seven Year Itch, sold for $4.6 million in 2011, reflecting their cultural and monetary value. Auctions like those conducted by Prop Store or Julien's Auctions also allow studios to recoup production costs. The rise of online auction platforms has made film memorabilia accessible to a global audience. (Retrieved from Julien's Auctions). Many costumes, especially those from lower-budget films, are reused in other productions. Costume rental houses like Western Costume Company or Angels Costume House hold extensive collections, renting costumes to filmmakers, theaters, and historical reenactors. This practice is both economical and environmentally conscious. Costumes from major franchises often end up in themed exhibitions or theme parks. For example, costumes from Harry Potter are showcased in Warner Bros. Studio Tour London, while Marvel costumes are displayed in Avengers Campus attractions. These exhibitions not only generate revenue but also deepen fan engagement. Sustainability is becoming a priority in the film industry. Costumes are often recycled or upcycled to reduce waste. Fabrics from costumes may be repurposed into new garments or used in set decorations. Some studios have adopted sustainability initiatives, donating unused costumes to charities or schools. In cases where costumes lack cultural or financial value, they may be discarded. Safety concerns, such as flammable materials, may necessitate destruction. Studios often balance the cost of preservation against the value of the costumes, leading to tough decisions. The disposal or destruction of movie costumes raises ethical questions about waste and sustainability. As the film industry grapples with environmental responsibility, there is increasing pressure to adopt sustainable practices in costume design and disposal. Moreover, preserving costumes holds cultural importance, as they serve as artifacts of collective memory and artistic achievement.

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e ISSN: 2584-2854
Volume: 02
Issue:12 December 2024
Page No: 3736-3747

Costumes from The Lord of the Rings trilogy are meticulously preserved. Many of them are displayed in the Weta Workshop Museum in New Zealand, serving as a testament to the craftsmanship behind the films. Costumes from the Star Wars series have been widely auctioned, archived, and displayed. Iconic items, like Darth Vader's helmet, are part of museum exhibitions, while others are held in private collections. The futuristic and elaborate costumes of The Hunger Games were auctioned for charity, supporting various causes while offering fans a chance to own a piece of the franchise. Costume designer and stylist Navin Shetty who has worked on Himmatwala, and Agneepath, said that he approaches every film afresh without recycling the costumes used in an earlier project. Once the shoot is over, everything goes to the production house's. Some costumes were auctioned by the studio for good value, which were later donated to an NGO. Some actors may like an outfit and want to keep it but might not wear it in public but, keep it as a souvenir. Some stylists even redesign the outfits for the same studio but in a completely different way. They are later styled differently and worn in other movies by junior artistes, Ahluwalia S (2018).

4. The Carbon Footprint of Movie Costumes

The entertainment industry, particularly film production, is a significant contributor to global carbon emissions. While the environmental impact of film sets and special effects is well-documented, the carbon footprint of movie costumes remains a less-explored topic. Costumes are essential to a film's visual narrative, yet they involve several stages that contribute to environmental degradation. Costumes in cinemas are traditionally cared for on set by workers known as dressmen. Dressmen have always employed informal methods and techniques in their work, and they now find their skills, knowledge, Clare M. Wilkinson-Weber (2006). Costumes are readily translatable into the commoditized clothing that is part of the new consumerism: they signal high production values; they are complicit in the construction of contemporary stardom; and they embody "professionalism" via the employment of well-connected fashion designers. At the same time, by illustrating the limits of masquerade or by reconfiguring the dilemmas of modernity as a myth, costume assists in the projection of themes that are more conservative than those of each film's forerunners. Clare M. Wilkinson-Weber (2010). The Lord of the Rings series also consumed a great deal of raw materials, with 48,000 pieces of armour, 10,000 arrows, 500 bows, 10,000 orc heads, and 19,000 costumes created exclusively for filming of these movies (Sibley et al. 2002). Apart from film but also the award for the best costume design is highly competitive because costumes arouse audiences' interest by maximizing visual effects in the movie and enable audiences to understand time period of the movie and social status and characteristics of characters (Award for Best Costume Design, 2015). New technologies in garment production also played a role in influencing fashion as well. The development of inexpensive synthetic fabrics meant that glamorous costumes could be recreated with cheaper fabrics for everyday Popular Mechanics

4.1. Material Used

According to the Ellen MacArthur Foundation (2017), the fashion industry as a whole contributes over 92 million tons of waste annually, a portion of which is attributable to costume production. The Lord of the Rings trilogy, one of the largest and most visually complex film productions ever made, is a prime example of the environmental challenges in costume production. The elaborate armour and costumes for each character were made from a variety of materials, including leather, chain mail, and synthetic fabrics. Due to the large volume of costumes required, the production involved significant material consumption and waste. A study by the Environmental Media Association estimated that 10,000 costumes were used across the trilogy, generating a substantial carbon footprint (EMA, 2004). James Cameron's "Avatar" also provides insights into the environmental impact of movie costumes, particularly in the use of motion capture suits. These suits were custom-designed for the actors and involved the production of complex, high-tech fabrics and components. The creation and transportation of these specialized costumes had a high carbon cost, although the film's digital production reduced some of the environmental

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Volume: 02
Issue:12 December 2024
Page No: 3736-3747

burden associated with physical costume creation (Griffiths, 2010). The raw materials used in costume design, such as fabrics, dyes, and embellishments, significantly contribute to a film's overall carbon footprint. Dunlap (2015) says that the most costumes are made from synthetic fibres like polyester, nylon, or acrylic, which are petroleum-based and have a high environmental impact due to the energy-intensive processes involved in their production (Fletcher, 2014). L. Murray and Joseph K, Polyester, a widely used petroleum fibre, requires intensive energy and large amounts of crude oil during the manufacturing process, in which "emissions including volatile organic compounds, particulate matter, and acid gases such as hydrogen chloride" and wastewater that includes volatile monomers, solvents, and other by-products are emitted. Cotton is "one of the most water- and pesticide-dependent crops" (Claudio). During the cotton fabric manufacturing process, the produced "effluent may contain a number of toxics," which flow into stagnant ponds. Natural fibres like cotton, wool, and silk have a lower environmental impact, but their cultivation still involves the use of pesticides and water-intensive agricultural practices (Niinimäki, 2017).

4.2. 4Manufacturing Processes

The manufacturing of costumes involves several stages, from weaving or knitting fabric to dyeing and finishing. These processes require significant energy inputs, and the use of synthetic dyes can lead to toxic runoff, contributing to water pollution (Lehmann et al., 2019). The transportation of costumes to film sets also adds to the carbon footprint, especially for international productions.

4.3. Transportation and Storage

Transportation of costumes from manufacturers to film sets, as well as the movement of costumes between filming locations, adds a significant amount to the carbon footprint. Many costumes are designed by ateliers or companies located far from the filming locations, requiring air or land transport. The storage of costumes between filming days also contributes to the carbon footprint, especially when large storage spaces are required.

4.4. Disposal

Once filming concludes, the costumes often end up in landfills or are incinerated, contributing to environmental degradation. The non-biodegradable synthetic fabrics used in many costumes take hundreds of years to decompose, releasing harmful chemicals into the environment (Kozlowski et al., 2015). Some costumes are donated to museums or recycled, but this is not always a feasible option.

5. Sustainable Practices in Movie Costume Design

In the realm of costume design, research serves as a foundation for creative expression and authenticity. Costume designers must delve into historical contexts, cultural significances, and material properties to create garments that not only reflect the character but also the world they inhabit. Turner, L. (2020) suggests that by engaging in thorough research, designers can draw from diverse influences, ensuring that the costumes resonate with audiences on a deeper level, ultimately enhancing storytelling. For instance, the integration of eco-efficient product-service system (PSS) innovations can contribute to sustainable practices in costume manufacturing, further enriching the aesthetic appeal of designs while considering environmental impacts (Ceschin et al., 2010). Furthermore, the experience of professionals in costume design underscores the necessity of adopting methods from both traditional and digital realms, as seen in the integration of costume professionals into character art teams within the game industry. This interdisciplinary approach illustrates how research can bridge the gap between innovation and historical relevance, fostering a more immersive character portrayal (Salomaa et al., 2018). Garret Simmer (2023) says that to make the film industry more sustainable it should have sustainability teams, less filming on location, recycling of sets and costumes. Sustainable materials, such as organic cotton, hemp, or recycled fabrics, can help mitigate the environmental impact of movie costumes. However, these materials are not always accessible or practical for high-budget productions says Dunlap (2015). To reduce the carbon footprint, many designers are turning to sustainable materials such as organic cotton, hemp, recycled fabrics, and biodegradable fibres (Ellen MacArthur Foundation, 2020). By opting for eco-

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Issue:12 December 2024
Page No: 3736-3747

friendly alternatives, costume designers can significantly reduce the environmental impact of their creations. With growing awareness of environmental concerns, designers like Jacqueline Durran have incorporated sustainable fabrics in productions like Little Women (2019). Recycled and ethically sourced materials are increasingly valued in contemporary costume design (Durran, 2019). Reusing costumes across different productions is a practice gaining traction within the film industry. The reuse of costumes helps minimize waste and reduces the need for new materials. Notable examples include the use of costumes from previous films in new productions, such as historical costumes being reused in period dramas. Some production companies are now incorporating sustainability into their operations by adopting green production standards. The Green Production Guide, for instance, offers resources and best practices for reducing the carbon footprint of all aspects of film production, including costume design (Green Production Guide, 2020). By using energy-efficient lighting, minimizing waste, and sourcing sustainable materials, productions can lower their environmental impact. Advancements in digital technologies are enabling the creation of virtual costumes, reducing the need for physical materials entirely. In films like “The Matrix” and “Avatar,” costumes were designed digitally, which helped to mitigate the environmental impact (Valkenburg, 2021). Virtual costumes are especially relevant in science fiction and fantasy genres, where elaborate, otherworldly designs are often required. Additionally, innovative methods like digital pleating, explored in recent textile research, highlight the importance of marrying traditional techniques with modern technology. By utilizing materials and methods that complement the characters narrative and movement, designers can create costumes that resonate with audiences while maintaining practicality in use (Huang et al., 2020). Ultimately, thoughtful selections in fabric and construction lead to costumes that are not only visually captivating but also functional within their intended contexts. Thermoplastics, such as EVA foam and Worbla, are popular in creating armour and props due to their moldability. Ruth Carter used 3D-printed designs for Black Panther (2018) to achieve intricate, Afro-futuristic aesthetics (Carter, 2018). Costumes integrating LED lights and fibre optics are used for futuristic and fantasy settings. Tron's (2010) glowing suits, designed by Michael Wilkinson, showcased technological integration to enhance visual storytelling (Wilkinson, 2010). Tools like CLO 3D and Adobe AI allows designers to create virtual prototypes, reducing the need for physical samples enhance costume design by simulating how fabrics and patterns behave in real-time, reducing the need for physical prototypes. Thus, minimized material use in testing and creates less chance of iterations required for approval, reducing fabric and energy consumption. Digital design minimizes material waste and accelerates the creative process.

5.1. AI for Sustainability

AI algorithms generate multiple costume variations based on director or designer inputs, optimizing design aesthetics while adhering to sustainability principles. They suggest designs that use pre-existing fabric scraps or eco-friendly materials. They ensure optimal fabric cutting layouts, reduces the waste during costume manufacturing. These algorithms calculate the most efficient way to cut patterns, minimizing leftover scraps. AI suggests sustainable and recyclable materials based on the design requirements, ensuring eco-friendly production choices. Intelligent software tracks costumes across productions, managing reuse and preventing overproduction. Helps to identity the available costumes in storage, reducing the need for new purchases or production. AI forecasts costume needs based on scripts and production schedules, ensuring only necessary items are created. It also identifies patterns in costume overuse or wastage, guiding future sustainability practices. For example, Netflix utilizes AI-driven systems to manage wardrobe assets across its multiple productions. AI-powered sorting systems categorize old costumes by fabric type, condition, and reusability, streamlining recycling efforts. These systems can suggest which costumes to upcycle, donate, or repurpose for new productions. AI-driven platforms allow filmmakers to catalogue and share costumes across studios, enabling efficient reuse. Studios can use blockchain technology

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Volume: 02
Issue:12 December 2024
Page No: 3736-3747

integrated with AI to track the lifecycle and ownership of costumes. AI creates virtual replicas (digital twins) of physical costumes, allowing directors to experiment with styles or modifications digitally before implementing changes on real garments. Costume fitting for actors can be simulated virtually, reducing the need for redundant physical adjustments. Algorithms calculate and reduce carbon emissions by optimizing costume transportation logistics, ensuring efficient delivery routes and schedules. Advanced AI models like GANs (Generative Adversarial Networks) create hyper-realistic digital costumes, eliminating the need for physical garment production. Like, Marvel and Disney frequently use AI-enhanced CGI for superhero and fantasy costumes. AI enables costumes to be digitally modified during post-production, reducing the need for reshoots due to wardrobe malfunctions or visual inconsistencies. It predicts how fabrics will wear and tear over time, enabling designers to choose longer-lasting materials with laundry and maintenance free. Reduces the number of duplicates required for costumes prone to damage. AI can be used to suggests optimal cleaning techniques for different fabrics, minimizing the environmental footprint of costume maintenance. AI quantifies the carbon emissions associated with costume production, helping studios implement greener alternatives. They can be used to monitor the lifecycle impact of costumes from sourcing to disposal.

6. Challenges and Future Directions

Eco-friendly materials and practices often involve higher upfront costs, which can deter productions with limited budgets. Many costume designers and production teams lack awareness of sustainable alternatives, hindering widespread adoption. Tight production schedules may prioritize speed and convenience over sustainable practices. Government and industry bodies can incentivize sustainable practices through tax breaks, subsidies, or recognition programs for eco-friendly productions. Investing in R&D for sustainable materials, such as bioengineered fabrics and biodegradable textiles, can expand options for costume designers. Partnerships between film studios, designers, and material scientists can accelerate the adoption of sustainable practices. Blockchain technology can track the lifecycle of costumes, ensuring transparency in sourcing, production, and disposal practices.

Conclusion

Fashion is an integral part of the movies and plays ‘a central role in constructing representations of identities and place’ therein, says Geczy A, Karaminas V (2016). Movie costumes, while pivotal in defining characters and enhancing narratives, pose several challenges and drawbacks in terms of production, usage, and broader implications. The carbon footprint of movie costumes is a significant yet underexplored part of film production. The environmental impact arises from material sourcing, manufacturing processes, transportation, and disposal. The film industry is gradually embracing sustainable practices, particularly in costume design, due to environmental concerns and the push for eco-conscious production. The use of eco-friendly materials, the recycling and reuse of costumes, and digital innovations like virtual costumes can help reduce the carbon footprint of movie costumes. Advances in fabric technology and sustainable practices continue to expand the horizons of costume design, enabling creators to achieve unprecedented levels of detail and functionality. The sustainable use of movie costumes is a vital step toward reducing the environmental impact of filmmaking. By embracing upcycling, rental systems, digital design, and eco-friendly materials, the industry can preserve artistic integrity while prioritizing sustainability. Collaborative efforts and innovative technologies are essential to drive this transformation. The adoption of these practices will not only enhance the industry’s environmental credentials but also set a precedent for other creative sectors to follow and also reduce pollution.

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Volume: 02
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