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SUSTAINABLE MATERIALS IN PUPPET-INSPIRED FASHION: ANALYSING ECO-FRIENDLY ALTERNATIVES WITH SUSTAINABLE MODEL

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ABSTRACT
Today, the fashion industry is heavily criticized because of the high level of environmental impact, excessive consumerism, and loss of traditional crafts. Therefore, sustainable fashion becomes a multifaceted model including ecology, ethics, and tradition. Puppet-based fashion, inspired by traditional theatrical performances, combines design techniques that blend performance and culture with traditional craftsmanship. However, choosing an appropriate material for fashion influenced by culture is difficult because of the many factors that play an important role in assessing its sustainability. This paper examines the suitability of sustainable textiles for puppet-inspired fashion apparel designs utilizing the FMCDM approach. Six types of sustainable textiles—organic cotton, hemp fiber, bamboo fiber, peace silk, linen, and recycled polyester—are assessed on the basis of six different attributes: environmental impact, functional properties, cost efficiency, compatibility with aesthetics, cultural significance, and acceptability among consumers. Opinions from experts are gathered based on linguistic variables, which are then subjected to fuzzy logic analysis. From this study, it has been observed that natural fiber-based fabrics, especially organic cotton and hemp fiber, are the best suited fabrics for puppet-inspired fashion apparel because of their relatively low environmental impact, adaptability to natural dyeing methods, and cultural significance.

Keywords: *Sustainable fashion; Puppet-inspired design; Eco-friendly textiles; Fuzzy logic; Cultural sustainability; Material evaluation*

1. INTRODUCTION
Indeed, the global fashion industry is one of the most environmentally impactful industries. As noted by Niinimäki et al. (2020), apparel production alone is responsible for about 10% of global carbon emissions and almost 20% of all industrial water waste. Furthermore, intensive reliance on synthetic materials, toxic dyeing, and energy-hungry manufacturing procedures have been identified as major environmental problems. On top of that, the adoption of fast fashion principles has made this issue even worse since they have led to increased overproduction, which results in very short lifecycles of garments and increased textile waste (Bhardwaj & Fairhurst, 2010). Hence, there is an urgent need to develop different production approaches that are sustainable from an environmental standpoint but economically viable at the same time. It is possible to achieve this objective by using the approach of sustainable fashion that promotes more eco-friendly and ethical ways of production.

Sustainable fashion also has several social and cultural aspects apart from being environmentally friendly. Globalization in the fashion industry is resulting in homogeneity, whereby the cultures of many communities are losing their uniqueness since the fashion industry tends to overshadow indigenous traditional arts and crafts. Cultural sustainability in the fashion industry involves preservation of traditional knowledge and skills, symbolic representations, and local culture through adaptation to modern designs (Manzini, 2015). This will help sustain the culture and ensure innovation at the same time. Traditional arts such as puppetry contain a vast body of knowledge of craft skills as well as cultural expression that has been practiced over centuries. Puppet costumes, which are an integral part of these performances, involve exaggerated silhouette designs, symbolic colors, beautiful embroidery, and hand-made designs. These are used to convey meaning through cultural expressions, as each costume represents social values and cultural identities of particular regions (Roy & Sen, 2011).

The inspiration behind puppet-inspired fashion is based on the aesthetics of puppet costumes, which are marked by exaggerated silhouette proportions, layering, brilliant use of color, and ornate decorations typical for puppet performances and their culture. Thus, these elements serve as the foundation for the development of storytelling in fashion, where garments can express stories of the heritage and culture of particular peoples and regions (Steele, 2010; Roy & Sen, 2011). Puppet-inspired fashion is another way through which fashion can be made sustainable and respectful to different cultures.

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However, despite its artistic beauty and uniqueness, translating the aesthetic of the puppets into clothing is not easy because costumes are designed first and foremost for the stage and not everyday use. This implies that many issues should be addressed in order to make clothing comfortable to wear and durable at the same time (Fletcher, 2014). Also, designers need to consider scalability and economic aspects of their work to achieve efficiency in mass production. As a consequence, material selection emerges as a crucial variable in the creation of puppet-inspired fashion. The designer faces the challenge of reconciling different and contradictory aspects, among which the aesthetic fit, cultural fit, eco-friendliness, economic affordability, and consumer acceptability should be mentioned. Such decision-making necessarily implies subjective perceptions and uncertainty due to the fact that some aspects of sustainability or cultural values cannot be quantified accurately. In such conditions, modern decision-making methods such as fuzzy logic become an important tool for assessing eco-friendly material alternatives (Zadeh, 1965; Tzeng & Huang, 2011).

This dissertation aims to conduct a study to reveal and evaluate eco-friendly textile material alternatives appropriate for puppet-inspired fashion. In its essence, the study is supposed to be based on the development of a systematic model to assess textile materials from the viewpoint of environmental, functional, economic, aesthetic, cultural, and other aspects. To ensure robust and flexible decision-making under uncertainty, a fuzzy multi-criteria decision-making (MCDM) model is applied for the evaluation and comparison of alternative materials. Based on this approach, sustainable textile options are ranked to recommend the most suitable materials for puppet-inspired fashion applications. Ultimately, the research aims to contribute a structured decision-support tool that facilitates informed, sustainable, and culturally sensitive material selection in contemporary fashion design.

2. REVIEW OF LITERATURE

2.1 Sustainable Fashion and Environmental Impact

The focus of sustainable fashion studies includes the minimization of negative environmental effects throughout the complete life cycle of textiles and garments from raw materials extraction to garment disposal. Conventional cotton farming, although it is natural fiber, requires large amounts of water and is highly dependent on the use of pesticides and fertilizers, resulting in land deterioration, water pollution, and increased water shortages (Muthu, 2014). At the same time, polyester and other artificial fibers, which are made of non-renewable sources of fossil fuels, constitute a significant threat to aquatic and terrestrial ecosystems due to microplastic pollution when washed (Niinimäki et al., 2020). The problem is addressed by the emergence of the concept of slow fashion, implying low production volumes, long product life cycles, ethical production processes, and emotional durability of products (Clark, 2008). Under the conditions of sustainable fashion, material innovation assumes particular importance since it involves the development of environmentally friendly fibers and advanced textile technologies.

2.2 Eco-Friendly Textile Materials

Organic cotton, hemp, bamboo, peace silk, linen, and recycled polyester are examples of some of the most commonly mentioned sustainable textile materials in current fashion studies. All these types of fabrics have both unique strengths and drawbacks in terms of their sustainability and functionality. Organic cotton is a popular sustainable fabric due to the absence of chemical fertilizers and pesticides used in its cultivation. This results in minimal soil and water pollution, as well as improved soil quality and biodiversity (Muthu, 2014). Nevertheless, this type of textile needs a considerable amount of water, especially when grown in dry climates. On the other hand, hemp fiber can be called one of the most sustainable crops among all textiles. It is characterized by reduced water consumption, fast growing, high fiber yield, and pest resistance (Das & Haque, 2020). The material's strength and breathability serve as additional qualities that make it appropriate for use in sustainable clothing manufacturing. The natural softness, antibacterial traits, and excellent moisture absorption properties of bamboo fiber make it ideal for comfortable wearables. Nonetheless, the sustainability issue arises in cases when bamboo is transformed into fibers using chemical-intensive processes, which may diminish its positive impact on ecology if not done carefully (Rana et al., 2021). Ahimsa silk or peace silk is an alternative that does not harm the life of silkworms; therefore, it is environmentally friendly and cruelty-free. Flax linen is one of the most environmentally friendly types of textiles since it is biodegradable, durable, and easy to be dyed using natural methods, thus making it perfect for eco-friendly and culturally inspired fashion brands. While recycled polyester is used for reducing waste, it is not biodegradable and raises ecological issues related to microfiber shedding.

2.3 Cultural Sustainability and Traditional Crafts

The concept of cultural sustainability emphasizes the conservation and perpetuation of intangible cultural heritage, which includes traditional skills, ceremonies, craft practices, and arts representing identity and values

of communities (Manzini, 2015). In the case of fashion, the incorporation of traditional crafts into design processes ensures not only the survival and preservation of heritage crafts that face a risk of extinction but also generates new business possibilities and fosters cultural pride and continuation of indigenous practices and knowledge systems in the contemporary world (Ghosh & Jain, 2022). Thus, heritage crafts provide sustainable fashion with unique characteristics, stories, and know-hows that make it culturally significant and emotionally engaging compared to conventional industrial clothing production. One of the most distinct types of traditional culture that can be used as a source of ideas for sustainable fashion is puppetry. Puppet costumes have many unique features, including peculiar color combinations and regional patterns, which carry rich cultural content and social meanings (Roy & Sen, 2011). Through reinterpretation of the aesthetics of puppets' clothes in terms of sustainable fashion design practices, one can create a fashion product line based on the traditional culture, contributing to both environmental and cultural sustainability simultaneously.

2.4 Puppet-Inspired Fashion and Theatrical Design

The key feature of theatrical fashion lies in its focus on dramatized shapes, visual storytelling, and ornamentation with symbolic content, which is beyond any utilitarian purpose (Steele, 2010). Designs created based on this concept derive their inspiration from the art of performing, folk culture, and other traditional practices, turning clothes into the tools of storytelling and emotional communication. The use of the principles of puppet fashion is close to theatrical fashion since it includes such components as exaggeration, articulation, layering, and decorative surface details that create the impression of dynamics and storytelling. The use of these elements provides the opportunity for reinterpretation of traditional puppet aesthetics and creation of innovative and culturally relevant garments.

In the case of the mentioned expressive fashion styles, the choice of materials is critical since it influences the interpretation of the conceptual ideas behind design projects and affects the comfort and flexibility of the resulting garment. In addition to the structural aspect, in the era of rising environmental concerns, the choice of sustainable materials is vital. Thus, eco-friendly textiles should be able to withstand complicated structures and provide comfort while minimizing their negative impact on the environment (Fletcher, 2014).

2.5 Fuzzy Logic in Sustainability Assessment

Theatrical fashion is defined by its use of dramatic silhouette shapes, visual storytelling, and ornamental symbolism to give more than just practical meaning to clothes (Steele, 2010). Clothes created using this aesthetic principle often borrow elements from performance art forms, folklore, and cultural traditions, elevating garments from utilitarian pieces to storytelling mechanisms. Similarly, the concept of puppet-inspired fashion is closely connected to theatrical fashion due to the presence of elements such as exaggerated form, articulation, layering, and decoration meant to express motion and create an additional narrative layer to the garment.

In such expressive fashion styles, the choice of textile becomes a vital element of transferring conceptual thoughts into actual wearable products. Textiles used for creating dramatic silhouettes affect both the stability and look of the design, as well as its overall wearability and wearer's comfort and mobility. Furthermore, with increasing environmental consciousness, it becomes important to utilize eco-friendly materials. In order to support such complex structures, sustainable textiles should also be durable and comfortable. Therefore, thoughtful material selection is fundamental to balancing theatrical expression, functional performance, and sustainability in puppet-inspired fashion design.

2.6 Research Gap

While many scholars have extensively examined sustainable textiles as well as fuzzy modeling for decisions, the relationship between sustainability and culture-based fashion design is yet to be adequately investigated. Puppet-related fashion design, with its vast array of stories and symbolism in terms of culture, has not found its place in sustainability assessment procedures. In this study, an effort will be made to bridge this crucial knowledge gap through the systematic examination of sustainable materials used in textiles as well as the incorporation of cultural considerations. Fuzzy models of decision making, in turn, allow taking into account the element of subjectiveness and uncertainty of various criteria.

3. RESEARCH METHODOLOGY

3.1 Research Design

A qualitative–quantitative hybrid research design is adopted. Secondary data were used to identify sustainable materials and evaluation criteria, while expert judgment formed the basis of fuzzy analysis.

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3.2 Selection of Material Alternatives

Six sustainable materials were selected based on literature relevance and applicability to puppet-inspired fashion:

- Organic cotton
- Hemp fiber
- Bamboo fiber
- Peace silk
- Linen
- Recycled polyester

3.3 Evaluation Criteria

The evaluation framework included six criteria:

1. Environmental impact
2. Functional performance
3. Economic feasibility
4. Aesthetic compatibility
5. Cultural authenticity
6. Consumer acceptance

3.4 Data Collection

Expert opinions were obtained from fashion designers, textile technologists, puppet artisans, and sustainability scholars. Evaluations were expressed using linguistic terms such as *Very High*, *High*, *Medium*, *Low*, and *Very Low*.

4. Fuzzy Model Application

In this study, linguistic assessments conducted through qualitative means from an expert standpoint have been systematically converted to triangular fuzzy numbers to deal efficiently with the elements of uncertainty and subjectivity in decision-making processes. Through the use of fuzzy numbers, a fuzzy decision matrix was constructed based on the performance of each material option with regard to the chosen evaluation criteria. This was normalized to make the criteria comparable regardless of different measurement units involved, which is further subjected to weighting based on their significance in the decision-making process. Lastly, defuzzification was applied to obtain crisp scores for the evaluation of sustainable materials (Zadeh, 1965; Tzeng & Huang, 2011).

4.1 Role of Fuzzy Logic in Sustainable Decision-Making

The concept of fuzzy logic introduced by Zadeh (1965) provides a powerful mathematical model to represent human reasoning when faced with conditions of uncertainty, vagueness, and ambiguity. Unlike classical binary logic, which confines the states of variables to either 'true' or 'false', fuzzy logic facilitates the possibility of elements belonging to various sets to different extents. The use of linguistic values like high, medium, or low, that better capture human reasoning and opinions, is one of the strengths of fuzzy logic models. In addition, fuzzy logic can be employed effectively in assessing sustainability-based criteria since most of these criteria, including environment, aesthetics, culture, and acceptability, cannot easily be represented in numerical terms. When it comes to assessing the long-term effects of environmental and socio-cultural factors, decision makers tend to depend on subjective expert judgment instead of objective data in sustainability assessments. However, fuzzy multi-criteria decision-making models provide a robust approach that incorporates the combination of subjective and objective factors through an integrated approach to analysis. For example, fuzzy analytical hierarchy process (FAHP) and fuzzy technique for order preference by similarity to ideal solution (Fuzzy TOPSIS) are some methods that have been used in sustainability assessments in various decision contexts. The use of fuzzy MCDM models has proven successful in previous research studies conducted on sustainable materials selection, supplier performance evaluation, and environmental performance assessment in different industry settings such as manufacturing, construction, and fashion industries (Tzeng & Huang, 2011).

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4.2 Explanation of Fuzzy Logic and Its Application in Sustainability Evaluation

Making decisions in such areas as sustainable development is often fraught with uncertainty, subjectivity, and incompleteness of data. The conventional quantitative approaches presuppose availability of exact numbers and boundaries; however, these assumptions are hard to meet in practice. Thus, fuzzy logic can become a perfect solution as an effective method that can model human thought process and make linguistic judgments possible. First proposed by Zadeh in 1965, fuzzy logic allows describing a situation through use of probability levels rather than binary options. Classical logic implies that each item or phenomenon is definitely present or not present within a set, meaning that the value will equal 1 or 0 correspondingly. At the same time, certain features of sustainability cannot be described in such terms. For example, such properties as sustainability, authenticity, or aesthetic compatibility are hard to categorize using only two categories. Therefore, such items as fabrics can display different degrees of sustainability but never be considered fully sustainable or fully unsustainable (Zadeh, 1965).

At the core of fuzzy logic lies the concept of a fuzzy set, which is defined by a membership function. The membership function assigns each element a value between 0 and 1, representing the degree to which it belongs to a particular set. A membership value of 0 indicates no membership, while a value of 1 denotes full membership. Intermediate values represent partial membership. This approach closely mirrors human reasoning, where assessments are often expressed using linguistic terms such as *low*, *medium*, or *high* rather than precise numerical values. For example, when evaluating the environmental sustainability of textile materials, experts may describe organic cotton as having a “high” environmental performance. In fuzzy logic, this linguistic assessment is transformed into a triangular fuzzy number, typically represented as ((l, m, u)), where (l) denotes the lower bound, (m) the most likely value, and (u) the upper bound. Such representation captures the inherent uncertainty in expert judgment and avoids the forced precision associated with single-point numerical values (Tzeng & Huang, 2011).

Triangular fuzzy numbers find extensive applications because of their easy application and comprehension. The membership function for a triangular fuzzy number starts at the lowest limit of the set, climbs steadily up to the mode, and then falls down to reach the highest limit. Thus, by its mathematical form, it allows us to translate the subjective judgment into a quantitative value without altering its essence. Therefore, fuzzy logic acts as an intermediary that translates human understanding into mathematical calculations. Fuzzy logic is especially beneficial when dealing with sustainable assessment, where different criteria need to be assessed together. Sustainability is a multidimensional concept that includes environmental considerations, economic feasibility, social acceptability, cultural acceptability, and aesthetic considerations. All these considerations are often contradictory and subjective. For instance, a material could be favorable for the environment but unfavorable economically and socially. While conventional decision-making approaches fail in handling such complexity, fuzzy logic offers the necessary adaptability to incorporate all the criteria under a single model (Zhang & Li, 2020). This integration is achieved through fuzzy multi-criteria decision-making (FMCDM) methods. FMCDM models enable decision-makers to evaluate multiple alternatives against several criteria using fuzzy numbers and linguistic variables. Well-known FMCDM techniques include the Fuzzy Analytic Hierarchy Process (FAHP) and Fuzzy Technique for Order Preference by Similarity to Ideal Solution (Fuzzy TOPSIS). These methods have been widely applied in fields such as supplier selection, sustainable material evaluation, energy planning, and environmental management (Tzeng & Huang, 2011).

In the context of sustainable material selection, FMCDM allows experts to assess materials based on criteria such as environmental impact, functional performance, cost, aesthetic compatibility, cultural relevance, and consumer acceptance. Each criterion is assigned a weight reflecting its relative importance, often derived through expert judgment. The performance of each material alternative under each criterion is expressed using fuzzy linguistic terms, which are then converted into fuzzy numbers to form a fuzzy decision matrix.

Once the fuzzy decision matrix is constructed, normalization and weighting procedures are applied to ensure comparability across criteria. The final step involves defuzzification, which converts fuzzy values into crisp scores to facilitate ranking and comparison. One commonly used defuzzification technique is the centroid or center-of-area method, which calculates the average of the triangular fuzzy number. This process yields a single representative value while preserving the uncertainty captured in the fuzzy model (Zadeh, 1965).

Empirical studies demonstrate that FMCDM models enhance the reliability and transparency of sustainability evaluations. By explicitly accounting for uncertainty and subjective judgment, fuzzy logic reduces bias and improves decision consistency. In sustainable fashion research, fuzzy models have been successfully applied to evaluate eco-friendly materials, assess green supply chains, and measure environmental performance under uncertain conditions (Zhang & Li, 2020).

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Moreover, fuzzy logic aligns well with culturally informed and design-oriented decision-making processes. In creative industries such as fashion, design judgments are rarely purely numerical; they rely heavily on expert intuition, experience, and aesthetic sensibility. Fuzzy logic allows these intangible factors to be systematically incorporated into analytical models, making it particularly suitable for evaluating culturally inspired and sustainable design alternatives.

In last, fuzzy logic provides a scientifically rigorous yet flexible framework for handling uncertainty, subjectivity, and qualitative assessment in sustainability evaluation. Its ability to integrate human judgment with mathematical modelling makes it a valuable decision-support tool for complex, multi-criteria problems. When applied through FMCDM techniques, fuzzy logic enhances the realism and effectiveness of sustainable decision-making, particularly in domains where environmental, cultural, and aesthetic considerations intersect.

Fuzzy logic, introduced by Zadeh (1965), provides a powerful mathematical framework for modelling human reasoning in situations where information is imprecise, uncertain, or subjective. Unlike classical binary logic, which restricts decision variables to crisp values such as 0 or 1 (true or false), fuzzy logic allows partial membership of elements within a set. This characteristic makes fuzzy logic especially suitable for sustainability assessment, where decision-making often depends on qualitative judgments rather than precise numerical data.

In fuzzy logic, a fuzzy set *A* defined on a universe of discourse (X) is characterized by a membership function $\mu_A(x)$, which assigns each element x ∈ X a membership value between 0 and 1:

$\mu_A(x) : X \rightarrow [0,1]$

Here, a value of 0 indicates no membership, while 1 indicates full membership. Values between 0 and 1 represent partial membership. For example, when evaluating the environmental impact of textile materials, an expert may describe organic cotton as having a "high" sustainability level rather than assigning an exact numerical score.

This linguistic term can be represented by a triangular fuzzy number Å = (l, m, u), where l, m and u denote the lower, most probable, and upper values, respectively:

Å = (l, m, u)

The membership function of a triangular fuzzy number is defined as:

$$\mu_{Å}(x) = \begin{cases} 0, & x < l \\ x-l/\ m-l, & l \le x \le m \\ u-x/\ u-m, & m \le x \le u \\ 0, & x > u \end{cases}$$

For instance, if the linguistic term "High environmental sustainability" is represented as (0.7, 0.9, 1.0)), then a material scoring 0.85 would have a high degree of membership in this fuzzy set.

In this manner, mathematical treatment of expert judgments can be done without having to force any form of precision on their assessments. Fuzzy Logic is used in FMCDM or fuzzy multi-criteria decision-making techniques, where decisions are based on multiple criteria being assessed. The assessment of materials in sustainability includes factors such as the environment, cost, aesthetics, and culture.

The fuzzy decision matrix $\bar{\mathbf{D}} = [\bar{x}_{ij}]$ is constructed

where $\bar{x}_{ij}$ represents the fuzzy performance rating of alternative i under criterion j.

After normalization and weighting, a defuzzification process is used to convert fuzzy values into crisp scores. One commonly used defuzzification method is the centroid method:

C (Å) = l + m + u/ 3

Fuzzy multi-criteria decision-making tools have been demonstrated to be effective means in sustainable material selection and supplier assessment through the integration of human factors and uncertainty in decision-making (Zadeh, 1965; Tzeng & Huang, 2011). Fuzzy logic is therefore an important analytical tool in sustainability-based product design and assessment.

4. RESULTS AND DISCUSSION

The FMCDM approach offered a systematic and thorough analysis of six sustainable textile materials utilized in puppet-inspired fashion, considering such factors as ecological considerations, functional properties, economic feasibility, aesthetic aspects, cultural suitability, and consumer perceptions. The findings suggest that materials based on natural fibers are superior to semi-synthetic and recycled fabrics because of their well-balanced sustainability features and culturally significant implications. Organic cotton is identified as the best material choice among those considered since it possesses relatively low environmental footprints, is comfortable for wearing, can be easily dyed using natural substances, and enjoys widespread consumer acceptance. Hemp fiber occupies second place due to its impressive ecological characteristics, high strength, lack of resource consumption, and compliance with the cultural traditions of textile crafting. Linen and peace silk have moderate scores because they are aesthetically pleasing and culturally authentic; however, higher costs and lack of large-scale production limit their applicability. The last two materials – bamboo fiber and recycled polyester – rank lowest due to the high environmental risks respectively, with regards to chemicals and microplastics release.

The use of the fuzzy MCDM methodology helped to yield coherent and understandable results of sustainable material evaluation. In particular, after normalizing and weighting the input parameters, the application of the centroid defuzzification technique helped transform triangular fuzzy numbers into numeric values. Thus, it was possible to make clear comparisons between the various material options. In addition, the obtained results indicated significant differences in performance levels of certain material options depending on their characteristics. In particular, eco-friendly materials scored higher since they were evaluated as superior across several criteria. In addition, the presence of strong environmental and cultural features helped some materials maintain high positions in spite of poor economic feasibility. Thus, as evidenced by the ranking outcomes, the use of fuzzy MCDM is highly efficient when it comes to combining human judgment and quantitative approach to material evaluation. These findings align with earlier research emphasizing the suitability of fuzzy logic for sustainability-driven material selection in fashion (Fletcher, 2014; Niinimäki et al., 2020). Overall, the proposed approach offers a structured, adaptable decision-support tool that facilitates informed, culturally sensitive, and sustainable fashion design under real-world complexity and uncertainty.

5. CONCLUSION

From a fuzzy multi-criteria decision-making perspective, this paper provides conclusive evidence that sustainable materials, especially organic cotton and hemp fiber, have high potential in puppet-inspired fashion. It shows that by merging sustainable textile materials with culture, there exists a viable strategy for developing responsible and creative fashion products. The results suggest that there is need to apply an adaptive and integrative approach in selecting materials based on considerations of environmental sustainability, functional properties, economics, aesthetics, culture, and consumer preferences. The utilization of the FMCDM technique has been instrumental in mitigating uncertainties and vagueness associated with design choices that prioritize sustainability. The analysis shows that the natural fiber-based materials outweigh the semi-synthetic and recycled fibers in puppet-inspired fashion. Organic cotton was established as the most efficient and optimal alternative. On the other hand, the environmental and cultural attributes of hemp fiber made it highly appropriate for puppet-inspired fashion. Linen and peace silk could be used in premium fashion designs due to their high cultural value, but their cost-effectiveness remains questionable. Importantly, this study highlights the value of fuzzy logic in combining qualitative expert insights with quantitative evaluation, ensuring transparent and robust decision-making. It further advances sustainable fashion discourse by linking cultural preservation—particularly puppetry traditions—with material sustainability. Overall, the research underscores that true sustainability in fashion must integrate environmental responsibility with cultural continuity and informed material choices.

6. IMPLICATIONS OF THE STUDY

In terms of scholarly contributions, the current study can be considered a valuable addition to the existing knowledge in the domain. It expands on the existing literature as it involves the analysis of cultural heritage alongside fuzzy multi-criteria decision-making approaches to material evaluation. Through an interconnection between analytical modelling and qualitative attributes such as sustainability and culture, it provides a methodological approach to dealing with the issues of uncertainty and subjectivity related to fashion decisions. On the side of applications within the fashion industry, the framework of evaluation suggested can become

useful for fashion designers and product developers in choosing appropriate sustainable materials for their designs. It is a versatile tool that takes into consideration various criteria including environmental, functional, economic, aesthetical and cultural aspects which can help in making sound decisions. Socially and culturally, the research supports artisan-based production systems by emphasizing materials compatible with traditional craft practices. It contributes to the preservation and revitalization of intangible cultural heritage by encouraging the integration of traditional aesthetics and skills into contemporary fashion, thereby fostering cultural continuity and inclusive sustainable development.

7. LIMITATIONS AND FUTURE RESEARCH

However, there are a number of issues related to this study that should be considered. First, sustainable material selection in this paper was carried out using experts' assessments in linguistic terms and using secondary sources of information. Although fuzziness helps to solve problems associated with subjective and uncertain factors in decision making, individual views and assessments of material sustainability may differ because of various reasons such as personal bias or contextual considerations. Furthermore, this research did not include quantitative indicators for evaluating the performance of different materials through life cycle assessment (LCA). This approach does not take into account consumer survey data about their preferences and attitudes to puppet-inspired sustainable fashion.

The main directions of future research can be focused on applying quantitative LCA measures along with fuzzy multiple criteria decision making methods. For instance, using consumer survey data will allow obtaining more detailed information about people's preferences, their willingness to pay, and even cultural considerations. What is more important, the application of fuzzy models in AI and machine learning will contribute to making better predictions, automating weighting, and supporting decisions dynamically.

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