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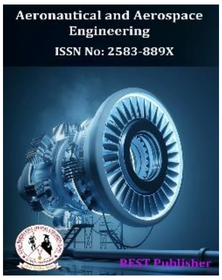


# Eco-Friendly Decorative Materials for Interior Design: A Multi-Criteria Evaluation Using the Weighted Sum Model

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***Abstract:*** *The rise in environmental consciousness has spurred a greater need for environmentally friendly decorative materials in furniture and interior design. Yet, current research lacks a thorough assessment of the environmental advantages of these materials within indoor environments. To fill this void, this paper assesses the environmental effects and examines the manufacturing processes of environmentally friendly decorative materials for indoor design. It starts by examining the categories and criteria for selecting environmentally friendly decorative materials, then describes the procedure for creating wood finishes for these materials. Selecting the right materials is vital for manufacturing firms to improve material characteristics and durability, especially in construction and decoration. It is recommended to use a combined multi-criteria decision-making approach that incorporates the Weighted Sum Model in order to select the best eco-friendly ornamental materials. The hierarchical index structure assigns weights to interior environmental aspects like physiological comfort, psychological satisfaction, and environmental impact. Using the WSM, these weights are used to rank eco-friendly decorative materials and identify the most suitable option. The suggested methodology is validated using a case study that includes ten distinct kinds of solid wood. Furthermore, nine trials are included in a sensitivity analysis to assess the consistency of the ranking results. The results indicate that this approach offers a logical and effective decision-making tool for assessing the efficacy of eco-friendly decorative materials.*

***Key Words:*** *WSM,* HVAC) systems, Quercus mongolica.

## 1. INTRODUCTION

In many engineering applications, material selection is an essential part of the design and manufacturing process. receiving considerable focus from researchers in recent times. Incorrect material choices can detrimentally affect product performance and longevity, resulting in increased costs and premature product obsolescence. Contemporary studies on material selection concentrate on three primary aspects: evaluating each material possibility, prioritizing and weighing relevant criteria, and creating a logical hierarchical framework based on several concepts and criteria. This approach has found extensive application in numerous sectors, especially in construction and decoration. Urbanization and economic globalization have spurred rapid manufacturing and infrastructure growth in China, with the construction industry emerging as a key sector. This growth has led to an increased emphasis on higher standards of living, aesthetics, and comfort in interior spaces. As a result, there is a rising significance placed on interior environmental characteristics in green decorative materials. Interior environmental characteristics are vital considerations in building decoration materials, including factors like physiological comfort, personal satisfaction, building conditions, and environmental features. Ling [2] emphasized that current research is particularly concerned with the functionality and Environmental friendliness of nanoparticles used in interior decoration. To find out how ornamental nanoparticles affect interior design and the use of environmental protection principles, they carried out three survey studies. Additionally, they contrasted the environmental properties of ecologically friendly nanomaterials with those of traditional ornamental materials. The findings from these experiments indicate that using green nanomaterials in indoor decorative design leads to a reduction in the emission of harmful and toxic substances. Lu [2] conducted a study cantered on a construction project, where they monitored different types of pollution sources, including gaseous pollutants, solid pollutants, water pollution, light pollution, and noise pollution at the construction site. According to their study, designing heating, ventilation, and air conditioning (HVAC) systems specifically for green buildings, structural optimization, and comprehensive design strategies for energy conservation and environmental protection are all necessary to achieve high-quality construction of green buildings. An automated temperature-controlling system for green ornamental materials was developed by Wang and Li [2]. This technology combines energy-saving green indoor ornamental materials with high-performance phase change composites. This system is based on phase change composites and is designed to regulate indoor temperature effectively. In highlighting the current trend in construction materials, Ryder pointed out that while new, environmentally friendly materials can suit the needs of the modern world, traditional materials are insufficient. They described the applications of a number of cutting-edge eco-friendly building materials. Li also went over a number of commercial procedures for applying eco-friendly, low-cost, user-friendly indoor design coatings that require nothing in the way of equipment or capital expenditure. This study introduces a hierarchical structure for assessment indicators and criteria that specifically target interior environmental characteristics. This structure can be applied in the evaluation process for selecting environmentally friendly decoration materials. Assessing different material options is essential for choosing environmentally friendly decoration materials. However, the presence of numerous selection criteria and intricate relationships among them makes this process challenging. For example, a variety of internal criteria, including tactile, olfactory, optical, and acoustic aspects, must be taken into account while analysing interior environmental qualities. Consequently, a useful technique for managing this complexity is the multi-criteria decision-making (MCDM) method. Generating alternatives, creating a criteria system, deciding on criteria weights, assessing alternatives, and putting a ranking system in place are the five primary parts of MCDM. Within the decision framework, each criterion is linked to a specific aim. Standardization is used to bring disparate criteria into a common measurement. In real-world applications, the Weighted Sum Model (WSM) method is often used for assessment. However, there are a few issues and disadvantages with it that need to be fixed.

## 2. MATERIALS AND METHOD

Given its economic, environmental, and aesthetic characteristics, solid wood has emerged as a prevalent decorative material in the construction industry. Following an initial screening process, ten types of solid woods have been identified as potential green decoration material alternatives for empirical analysis. These include Quercus mongolica, Pterocarpus santalinus, Larix gmelini, Abies nephrolepis, Pinus sylvestris var. mongolica, Pinus koraiensis, Picea jezoensis, Juglans mandshurica var. microsperma, Betula platyphylla, and Fraxinus mandshurica. To determine the optimal choice for decorative material, a range of quantitative and qualitative factors must be included in the hierarchical structure. These standards include a variety of elements, including fire resistance, health and safety concerns, and the initial cost of purchasing. Depending on the kind of material, these requirements may or may not be important. The target level, criterion level, and sub-criterion level comprise the three-level hierarchy that the study uses to arrange interior environmental characteristics. Environmentally friendly decoration materials are evaluated at the aim level, while other factors such as architectural physics, living body considerations, tactile, olfactory, and visual features are covered at the criterion level. Initial data and pertinent information were collected from experts in different fields, including college scholars and enterprise supervisors, through questionnaire surveys. For this study, eight experts were consulted: two consumers with over three years of experience using these items, three supervisors from reputable companies, and three specialists in material selection. These interviews were used to create the pair-wise comparison matrix for each criterion and the decision matrix for choosing the best material.

**Weighted Sum Model (WSM):** One straightforward and often applied strategy in Multi-Criteria Decision Making (MCDM) is the Weighted Sum Model (WSM), also known as the Simple Additive Weighting (SAW) method. It involves applying the weights allocated to each criterion and totaling the criterion values for each choice. The WSM is often only used for benefit criteria. As a result, before normalization, cost criteria must be changed to benefit criterion. This transformation is simple: the criteria value under consideration is subtracted, and the maximum and minimum criterion values are added for each cost criterion. This conversion ensures that the highest value becomes the lowest-cost criterion value and vice versa. After cost criteria are converted into benefit criteria, only benefit values are used to create a new starting matrix. Next, each criterion value is divided by the sum of its row to generate the normalized matrix. The corresponding weight of each criterion is then multiplied by its value. The option with the highest value is ultimately selected as the best course of action after the values for each alternative have been added up. Bagočius et al. evaluated the best wind power plant based on technical, financial, and environmental factors using the WSM and the WPM. They determined that the WSM's simplicity and adaptability made it the best MCDM technique.

Even while more sophisticated approaches might be better for more complicated issues, it's important to thoroughly weigh the benefits and drawbacks of each approach before choosing one. The WSM presents a systematic solution to the issue, providing a clear synopsis of the criteria, options, and weights and scores associated with each. It presents a simpler and more direct method for addressing multi-criteria problems, facilitating the prioritization of criteria and comprehension of the entire computational process. The WSM method entails creating a decision matrix to record performance ratings for each alternative across all criteria. This matrix is normalized to standardize all criteria onto the same scale. Subsequently, the normalized matrix is weighted according to the relative significance of each criterion. The Preference Score for each alternative is determined by adding up the weighted scores, enabling a comparison of overall performance. Ultimately, the alternative with the highest Preference Score is chosen as the optimal choice, offering a straightforward ranking of alternatives based on their performance across the designated criteria.

## 3. RESULTS AND DISCUSSION

**TABLE 1.** Data Set

| | visual | acoustic | tactile | olfactory | architectural physics | living body |
|---|---|---|---|---|---|---|
| Quercus mongolica | 6 | 5 | 5 | 5 | 7 | 5 |
| Pterocarpus santalinus | 7 | 6 | 5 | 7 | 7 | 6 |
| Larix gmelini | 6 | 6 | 5 | 6 | 7 | 5 |
| Abies nephrolepis | 6 | 4 | 7 | 5 | 7 | 5 |
| Pinus sylvestris var. mongolica | 6 | 5 | 6 | 6 | 7 | 5 |
| Pinus koraiensis | 6 | 5 | 6 | 6 | 7 | 6 |
| Picea jezoensis var.microsperma | 5 | 7 | 7 | 6 | 7 | 5 |
| Betula platyphylla | 5 | 6 | 6 | 5 | 7 | 5 |
| Fraxinus mandshuric | 7 | 6 | 5 | 5 | 7 | 5 |
| Juglans mandshurica | 6 | 4 | 7 | 5 | 7 | 5 |

Table 1 presents a dataset for evaluating green decoration materials based on various criteria related to interior environmental characteristics. The criteria include visual appeal, acoustic properties, tactile sensation, olfactory characteristics, architectural physics, and impact on living organisms. Each criterion is rated on a scale from 1 to 10 for ten different types of solid woods: Quercus mongolica, Pterocarpus santalinus, Larix gmelini, Abies nephrolepis, Pinus sylvestris var. mongolica, Pinus koraiensis, Picea jezoensis var. microsperma, Betula platyphylla, Fraxinus mandshuric, and Juglans mandshurica. These ratings provide a quantitative basis for comparing the performance of each wood type across the specified criteria, aiding in the selection of the optimal green decoration material.

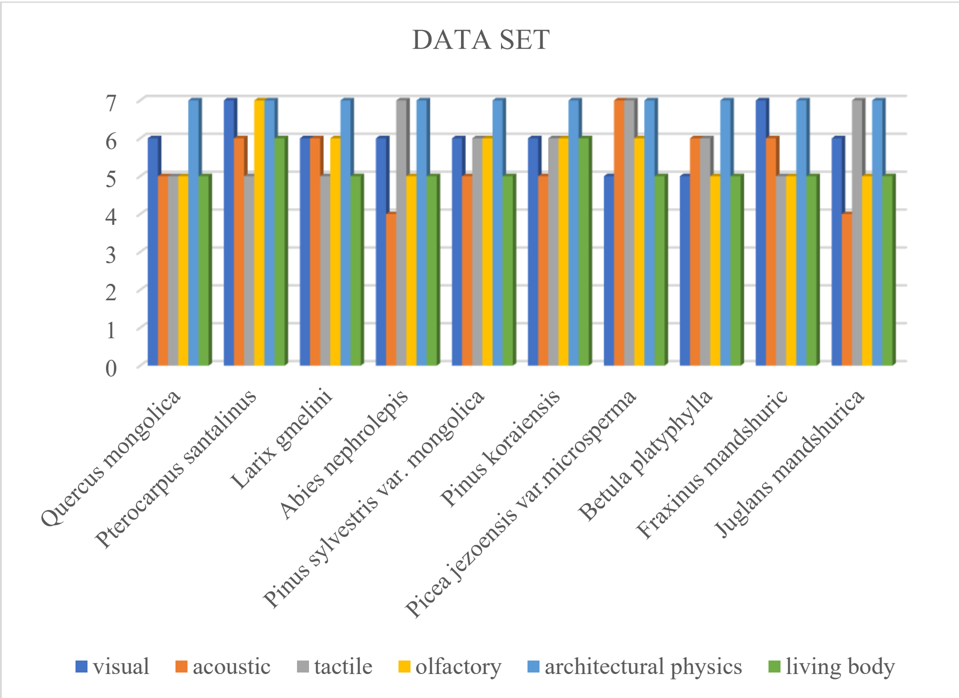


**FIGURE 1.** Data set

Figure 1 displays the raw data set for each criterion for all alternatives. The values represent the subjective ratings given to each material for its performance in the specified criteria. These ratings serve as the basis for calculating the normalized scores.

**TABLE 2.** Normalized

| | visual | acoustic | tactile | olfactory | architectural physics | living body |
|---|---|---|---|---|---|---|
| Quercus mongolica | 0.85714 | 0.71429 | 0.71429 | 0.71429 | 1.00000 | 1.00000 |
| Pterocarpus santalinus | 1.00000 | 0.85714 | 0.71429 | 1.00000 | 1.00000 | 0.83333 |
| Larix gmelini | 0.85714 | 0.85714 | 0.71429 | 0.85714 | 1.00000 | 1.00000 |
| Abies nephrolepis | 0.85714 | 0.57143 | 1.00000 | 0.71429 | 1.00000 | 1.00000 |
| Pinus sylvestris var. mongolica | 0.85714 | 0.71429 | 0.85714 | 0.85714 | 1.00000 | 1.00000 |
| Pinus koraiensis | 0.85714 | 0.71429 | 0.85714 | 0.85714 | 1.00000 | 0.83333 |
| Picea jezoensis var.microsperma | 0.71429 | 1.00000 | 1.00000 | 0.85714 | 1.00000 | 1.00000 |
| Betula platyphylla | 0.71429 | 0.85714 | 0.85714 | 0.71429 | 1.00000 | 1.00000 |
| Fraxinus mandshuric | 1.00000 | 0.85714 | 0.71429 | 0.71429 | 1.00000 | 1.00000 |
| Juglans mandshurica | 0.85714 | 0.57143 | 1.00000 | 0.71429 | 1.00000 | 1.00000 |

Table 2 shows the normalized values for each criterion for the ten different types of solid woods used in the evaluation of green decoration materials. The normalization process scales the ratings for each criterion to a range between 0 and 1, allowing for a more meaningful comparison between different criteria. For example, Quercus mongolica has a normalized visual score of 0.85714, indicating that it performs well visually relative to the other woods. Similarly, Pterocarpus santalinus has a normalized acoustic score of 0.85714, suggesting that it excels in acoustic properties compared to the other woods. These normalized values provide a standardized basis for comparing the performance of each wood type across the various criteria.

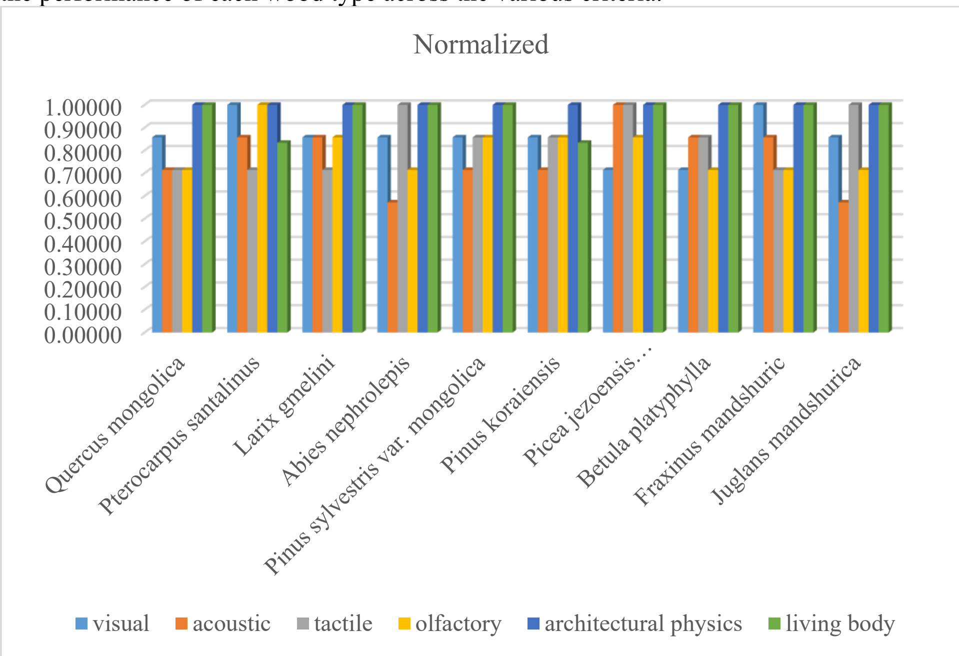


**FIGURE 2.** Normalized

Figure 2 presents the normalized scores for various criteria for each alternative material. The scores are standardized to ensure comparability across criteria. The values represent the performance of each material relative to the others, with higher values indicating better performance.

**TABLE 3.** Weight

| | visual | acoustic | tactile | olfactory | architectural physics | living body |
|---|---|---|---|---|---|---|
| Quercus mongolica | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| Pterocarpus santalinus | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| Larix gmelini | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| Abies nephrolepis | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| Pinus sylvestris var. mongolica | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| Pinus koraiensis | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| Picea jezoensis var.microsperma | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| Betula platyphylla | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| Fraxinus mandshuric | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Juglans mandshurica | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |

Table 3 displays the weights assigned to each criterion for the evaluation of green decoration materials using the ten different types of solid woods. Each criterion, including visual appeal, acoustic properties, tactile sensation, olfactory characteristics, architectural physics, and impact on living organisms, is assigned an equal weight of 0.17. This equal weighting implies that each criterion is considered equally important in the evaluation process, ensuring a balanced assessment of the performance of each wood type across all criteria.

**TABLE 4.** Weighted normalized decision matrix

| | visual | acoustic | tactile | olfactory | architectural physics | living body |
|---|---|---|---|---|---|---|
| Quercus mongolica | 0.14229 | 0.11857 | 0.11857 | 0.11857 | 0.16600 | 0.16600 |
| Pterocarpus santalinus | 0.16600 | 0.14229 | 0.11857 | 0.16600 | 0.16600 | 0.13833 |
| Larix gmelini | 0.14229 | 0.14229 | 0.11857 | 0.14229 | 0.16600 | 0.16600 |
| Abies nephrolepis | 0.14229 | 0.09486 | 0.16600 | 0.11857 | 0.16600 | 0.16600 |
| Pinus sylvestris var. mongolica | 0.14229 | 0.11857 | 0.14229 | 0.14229 | 0.16600 | 0.16600 |
| Pinus koraiensis | 0.14229 | 0.11857 | 0.14229 | 0.14229 | 0.16600 | 0.13833 |
| Picea jezoensis var.microsperma | 0.11857 | 0.16600 | 0.16600 | 0.14229 | 0.16600 | 0.16600 |
| Betula platyphylla | 0.11857 | 0.14229 | 0.14229 | 0.11857 | 0.16600 | 0.16600 |
| Fraxinus mandshuric | 0.16600 | 0.14229 | 0.11857 | 0.11857 | 0.16600 | 0.16600 |
| Juglans mandshurica | 0.14229 | 0.09486 | 0.16600 | 0.11857 | 0.16600 | 0.16600 |

Table 4 presents the weighted normalized decision matrix for the evaluation of green decoration materials using the ten different types of solid woods. Each cell in the matrix represents the product of the normalized score and the corresponding weight for each criterion. For example, for Quercus mongolica, the weighted normalized visual score is 0.14229, which is calculated by multiplying the normalized visual score (0.85714) by the weight for visual (0.17). Similarly, the weighted normalized acoustic score for Quercus mongolica is 0.11857, calculated as the product of the normalized acoustic score (0.71429) and the weight for acoustic (0.17). These calculations are repeated for each criterion and wood type, resulting in a comprehensive matrix that considers the relative importance of each criterion in the evaluation process.

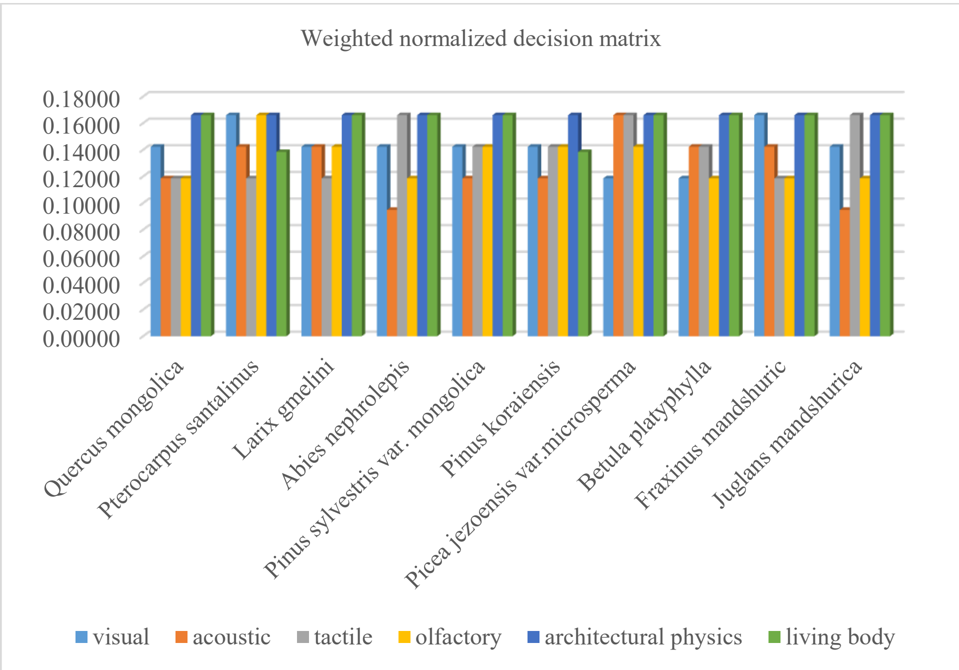


**FIGURE 3.** weighted normalized decision matrix

Figure 3 presents the weighted normalized decision matrix, which combines the normalized scores with the weights assigned to each criterion. The values reflect the overall performance of each alternative, considering both the relative importance of each criterion and their individual scores.

**TABLE 5. Preference Score**

| | Preference Score |
|---|---|
| Quercus mongolica | 0.83000 |
| Pterocarpus santalinus | 0.89719 |
| Larix gmelini | 0.87743 |
| Abies nephrolepis | 0.85371 |
| Pinus sylvestris var. mongolica | 0.87743 |
| Pinus koraiensis | 0.84976 |
| Picea jezoensis var.microsperma | 0.92486 |
| Betula platyphylla | 0.85371 |
| Fraxinus mandshuric | 0.87743 |
| Juglans mandshurica | 0.85371 |

Table 5 shows the Preference Score for each of the ten different types of solid woods evaluated as green decoration materials. The Preference Score is calculated by summing the weighted normalized scores for each criterion for each wood type. For example, Picea jezoensis var. microsperma has the highest Preference Score of 0.92486, indicating that it is the most preferred wood type based on the evaluation criteria. On the other hand, Quercus mongolica has a Preference Score of 0.83000, indicating that it is less preferred compared to the other wood types. These scores provide a ranking of the wood types based on their overall performance across all criteria, helping to identify the optimal green decoration material.

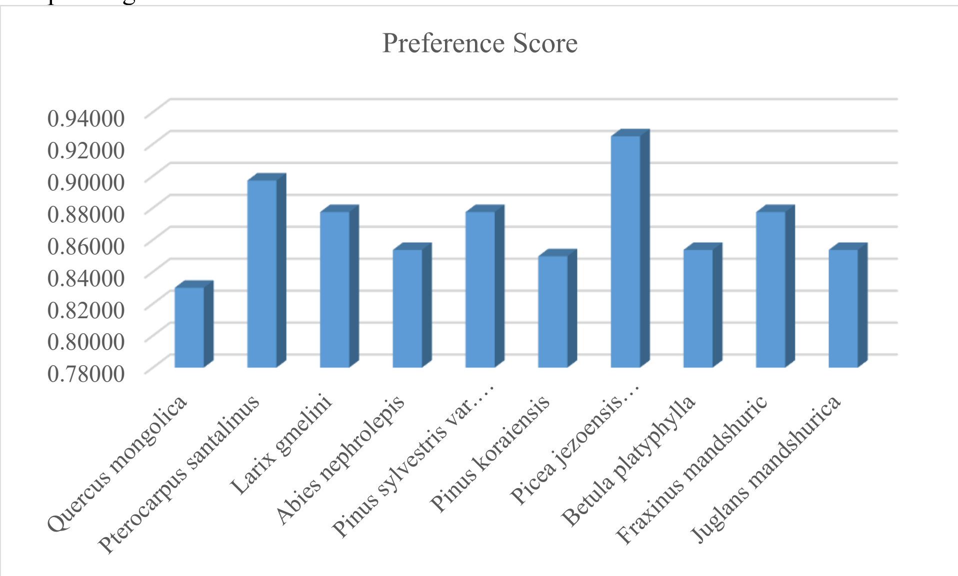


**FIGURE 4.** Preference Score

Figure 4 displays the Preference Score for each alternative, which is the sum of the weighted normalized scores across all criteria. The Preference Score indicates the overall ranking of each alternative, with higher scores indicating better performance.

**TABLE 6.** Ranking

| Rank | |
|---|---|
| Quercus mongolica | 10 |
| Pterocarpus santalinus | 2 |
| Larix gmelini | 4 |
| Abies nephrolepis | 7 |
| Pinus sylvestris var. mongolica | 3 |
| Pinus koraiensis | 9 |
| Picea jezoensis var.microsperma | 1 |
| Betula platyphylla | 6 |
| Fraxinus mandshuric | 4 |
| Juglans mandshurica | 7 |

 

Table 6 displays the ranking of the ten different types of solid woods as green decoration materials based on their Preference Scores. The woods are ranked from 1 to 10, with 1 being the most preferred and 10 being the least preferred. Picea jezoensis var. microsperma is ranked 1, indicating that it is the most preferred wood type based on the evaluation criteria. On the other hand, Quercus mongolica is ranked 10, indicating that it is the least preferred wood type. The rankings provide a clear hierarchy of the wood types in terms of their suitability as green decoration materials, helping decision-makers select the optimal material for their needs.

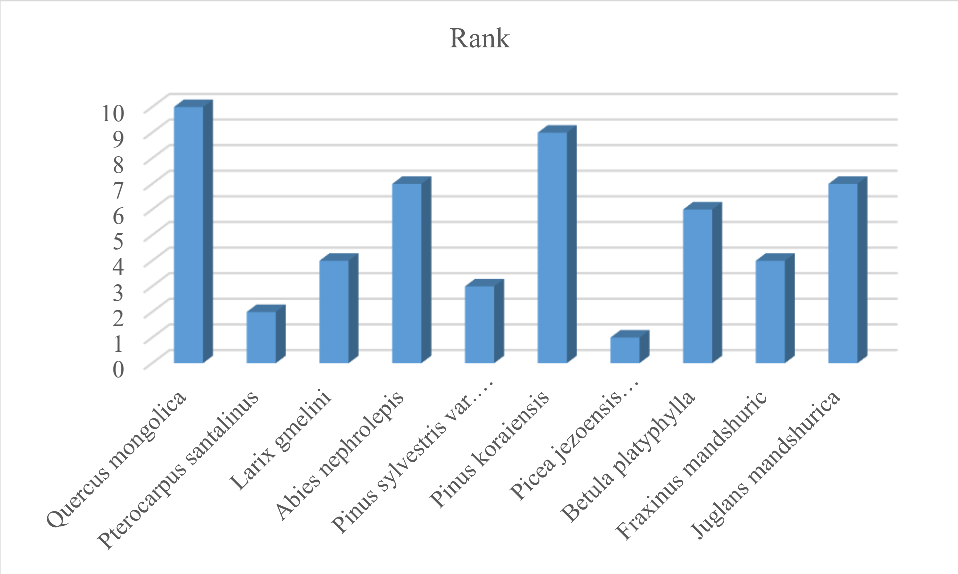


**FIGURE 5.** Ranking

Figure 5 presents the ranking of each alternative based on their Preference Scores. The Rank column indicates the position of each alternative in the ranking, with lower ranks indicating higher preference and better performance.

## 4. CONCLUSION

The evaluation of green decoration materials using the Weighted Sum Model (WSM) method provides a systematic and structured approach for decision-making. The process involves constructing a decision matrix, normalizing the matrix, assigning weights to criteria, and calculating a Preference Score for each alternative. This methodology allows for a comprehensive assessment of the performance of each material across various criteria, such as visual appeal, acoustic properties, tactile sensation, olfactory characteristics, architectural physics, and impact on living organisms. In this study, ten different types of solid woods were evaluated based on these criteria, and Picea jezoensis var. microsperma emerged as the most preferred wood type, while Quercus mongolica was the least preferred. These findings provide valuable insights for selecting the optimal green decoration material for interior design projects, ensuring that decisions are based on a thorough and objective analysis of the available alternatives.

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