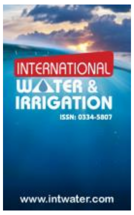

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Analysis of Multiple Attribute Decision Making in Artistic Photography

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***Abstract*:** Artistic photography is a complex kind of visual art that relies on the careful selection of materials to accomplish intended aesthetic and operational results. The substance used to make photographic prints has a considerable impact on their quality, longevity, and appearance. Given the wide range of material properties like texture, longevity, colour reproduction, expense, and impact on the environment, meticulously identifying and ranking the best materials for artistic photography is critical. Previous methods for material selection frequently lack complete frameworks for assessing and comparing materials across numerous aspects at once. This paper overcomes these restrictions by developing the Multiple Attribute Decision Making for Artistic Photography Material Ranking (MADART) algorithm. The MADART algorithm combines the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and Weighted Sum Model (WSM) techniques to present a systematic strategy for material choice, addressing the limitations of previous techniques. Experimental outcomes reveal that the MADART algorithm provides higher material selection effectiveness compared to existing methodologies, guaranteeing that photographers and industry professionals may make informed selections that maximize both artistic quality and practical implications.

Keywords: Multiple attributes, decision making, Artistic Photography, Material Selection, MADART, TOPSIS, WSM

1. Introduction

Artistic photography is a dynamic form of visual art in which the combination of creativity and technical competence produces attractive images [1]. The selection of proper materials is crucial to this creative procedure, since it has a considerable impact on the final product's excellence, durability, and appearance. Different materials, like glossy picture paper, matte canvas, metal prints, and acrylic sheets, have distinct characteristics that can either improve or detract from the artistic concept [2], [3]. Photographers must evaluate the texture, longevity, color reproduction, expense, and environmental influence of various materials in order to get the desired results [4], [5].

The necessity to choose the appropriate material for artistic photography originates from the unique needs of various photographic projects. Each material delivers a unique set of properties that can either support or undermine the artistic aim. For example, a material with wonderful color reproduction may lack the necessary longevity, while a low-cost choice may fall short in texture excellence. To create informed decisions which balance aesthetic, feasible, and financial factors, photographers must employ a systematic strategy to analyzing and ranking these materials.

Previous material selection strategies frequently depend on subjective assessments or simplified assessment techniques that do not take into consideration the diverse character of the decision-making procedure. Popular approaches may include simple comparisons of a few features or individual desires that lack the rigorousness and thoroughness required for an ideal decision. These conventional methodologies do not give a formal framework for assessing materials across numerous aspects concurrently, resulting to suboptimal selections and possible compromises in the appearance of photographic prints.

To solve these restrictions, this paper presents the Multiple Attribute Decision Making for Artistic Photography Material Ranking (MADART) method. The MADART algorithm is intended to give a reliable and systematic method for choosing materials in artistic photography. The MADART algorithm assesses and ranks materials using a broad set of criteria, incorporating sophisticated methods like the Weighted Sum Model (WSM) and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). This technique guarantees that all pertinent attributes are addressed, and trade-offs between competing criteria are thoroughly examined.

The MADART method takes an organized method for material selection, first normalizing data and addressing missing values to assure correctness. Weights are allocated to each attribute via InfoGainAttributeEval and Ranker search, followed by normalization. The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) identifies ideal and negative-ideal solutions, computes Euclidean distances, and evaluates their relative proximity to the ideal. The Weighted Sum Model (WSM) subsequently generates weighted scores for each material. At last, averaging the TOPSIS and WSM scores presents a holistic assessment of the materials, supporting an informed selection procedure. This paper provides remarkable contributions:

- Presents the new MADART algorithm for material selection in artistic photography.
- Presents a systematic and complete assessment of materials using several attributes.
- Empirical analysis shows the MADART algorithm's usefulness.
- Improves decision-making procedures in photographic creativity by enhancing material choices.

The goal of this study is to use MADART approaches to systematically discover and rank the finest materials for artistic photography, thus enhancing the excellence and consistency of photographic prints. The conclusions of this study are relevant to photographers, print studios, and industry experts that produce high-quality photographic prints. The MADART algorithm could also be used for choosing materials in other types of visual arts and printing applications.

The paper is divided into five main sections. Section 2: Related Works examines the pertinent literature on material selection techniques and decision-making structures, offering context and emphasizing gaps in previous studies. Section 3: Methodology describes the MADART algorithm, incorporating data preprocessing, weight assignment, and assessment methodologies, and explains the structured method employed in this work. Section 4: Experimental findings and discussion offer an empirical assessment and compares the MADART algorithm to other methodologies, showing its efficacy. At last, Section 5: Conclusion and Future Work reviews the paper's accomplishments and proposes areas for further investigation, highlighting the possibility for additional breakthroughs in material selection for artistic photography.

This study systematically addresses the complicated decision-making procedure involved in choosing materials for artistic photography, providing a significant tool for boosting both the artistic and practical sides of photographic output.

2. Related Works

Material selection for artistic photography necessitates a thorough comprehension of material qualities, functionalities, and how they affect visual outcomes. Prior research has investigated diverse approaches and materials, emphasized notable advances and persisted issues in the field.

Sharma et al. [6] developed a technique for choosing similar materials in photos by using unsupervised DINO features and a Cross-Similarity Feature Weighting module in conjunction with an MLP head to extract material commonalities. Their strategy, evaluated on both synthetic and real-world photos, proved sturdiness against shading and specular highlights, making major contributions to the area of image editing and material selection.

Rose [7] gave a detailed guide on visual approaches, highlighting the significance of developing research projects with visual materials and incorporating digital techniques. This study has assisted social researchers in artistically investigating and using images, establishing a core approach for comprehending visual materials in artistic photography.

Tang et al. [8] examined the uses of sophisticated multifunctional composite phase change materials (PCMs) using photosensitive materials. These materials have high energy storage capabilities and distinctive light sensitivities, opening up new possibilities for PCM uses. Their review emphasized the mechanisms and advances of photo-responsive composite PCMs, emphasizing the significance of incorporating novel functionalities beyond thermal energy storage.

Lin et al. [9] investigated the utilization of operational carbon nitride materials in photo-Fenton catalysis for environmental cleanup. Their review concentrated on novel engineering strategies for CN-based catalysts, such as morphological control and doping with metal-containing compounds. This work gives useful perspectives into the catalytic activity and structural features of CN-based photocatalysts, which are pertinent to environmental uses.

Feng [10] investigated the expansion of painting artwork with structural color materials and viewpoint projection simulation. The author investigated the historical implementation of optical technology and its influence on painting techniques. The author emphasizes the role of current technology in producing novel artistic techniques, which enhance the innovative opportunities for artists employing structural color pigments and ICT technology.

Zhou et al. [11] examined 3D printing methods for soft polymer materials, concentrating on difficulties and innovations in creating printable materials and enhancing printing quality and efficiency. Their review underlined the possible of 3D printing for building functional systems and structures, notably in uses like biological tissues.

Park et al. [12] gave a summary of 3D printing polymer composites, including design concepts, techniques, and new applications. Despite current advancements, they noted obstacles like inferior product excellence and restricted material availability for 3D printing, providing a thorough viewpoint on upcoming fields of study in additive production.

Kwon et al. [13] examined digital printing techniques for electronic materials, concentrating on different direct printing processes and uses. They examined the mechanics, printing algorithms, and high-resolution techniques appropriate for creating electronic materials, presenting a complete summary of the existing situation and upcoming possibilities in the area.

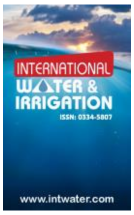
Lobinger [14] investigated photo-sharing activities from a texto-material standpoint, highlighting the significance of images as both objects and messages. This method gave a comprehensive comprehension of photo-sharing in modern visual interactions, underlining the legal constraints and possibilities of this widespread practice.

Bhardwaj et al. [15] investigated the dynamic tweaking of electromagnetic responsiveness in a self-assembled liquid crystal-nanoparticle hybrid material. Their research revealed photo-tunable epsilon-near-zero behavior in this material, underlining its promise as an effective ENZ metamaterial in the optical realm. This study emphasizes the significance of adjustable optical characteristics in modern material uses.

Material selection study frequently depends on subjective assessments or simplistic assessment techniques that fail to account for the complicated decision-making processes. Popular methods may include simple attribute assessments or individual choices, which lack the rigor required for optimal decisions. These conventional techniques frequently fail to give a formal structure to assess materials fully across numerous dimensions concurrently, possibly leading in suboptimal judgments and reducing the excellence of photographic prints. As a result, there is an obvious requirement for sophisticated methods including the MADART algorithm, which could give a methodical and logical method for material selection. MADART integrates numerous criteria and factors, allowing for better informed selections that improve the excellence and effectiveness of photographic prints.

3. Methodology

The Multiple Attribute Decision Making for Artistic Photography Material Ranking (MADART) algorithm is used in an organized and rigorous manner to identify the best materials for artistic photography. This complete procedure is intended to guarantee that each material is examined in numerous dimensions, so offering a solid



International Water and Irrigation
Volume 44 Issue 2 (2025)
ISSN: 0334-5807
Pages 249 - 259

foundation for creating optimum decisions. The methodology is separated into numerous important steps, each aimed at carefully dealing with data and employing advanced methods of decision-making to assess the materials using their overall potential for artistic photography.

3.1 Dataset

The dataset utilized in this study includes a diverse selection of materials often employed in artistic photography. Each material is examined using a comprehensive set of criteria to determine its eligibility for high-quality photographic prints. The materials in the collection are evaluated on factors like texture, longevity, color reproduction, reflectivity, expense, environmental impact, weight, print resolution, drying time, lightfastness, and scratch resistance.

The data was carefully gathered using an integration of laboratory measures and market analysis. Laboratory testing included employing sophisticated tools to guarantee accurate gathering of data for attributes such as texture (which is measured in microns utilizing a surface profilometer), color reproduction (which is measured in Delta E utilizing a colorimeter), reflectivity (which is measured as a percentage employing a reflectometer), and longevity (which is measured in cycles via rub or wear examinations). A market study was undertaken to acquire precise data on expense and impact on the environment, with credible sources used to verify data dependability. This method guarantees a strong and complete dataset, offering a solid platform to assess the feasibility of various materials for creative photography.

Table 1 displays a sample of the dataset, presenting a subset of materials along with their relevant attributes. This table presents a concise overview of the comprehensive dataset utilized in the study.

Table 1: Sample Dataset

Material,Texture (µm),Durability,Color Reproduction (Delta E),Reflectivity (%),Cost ($/sq.ft),CO2 Impact (kg/sq.ft),Weight (g/sq.ft),Print Resolution (dpi),Drying Time (sec),Lightfastness (years),Scratch Resistance (rating),Overall Score (Target)
Glossy Photo Paper,6,3000,4.0,90,3.50,0.4,190,1300,40,6,9,8.0
Matte Canvas,16,4000,5.0,30,4.00,0.3,460,700,56,9,8,7.9
Metal Print,11,1600,6.0,80,6.00,0.6,800,3500,20,30,8,7.8
Acrylic Sheet,3,5000,3.6,96,9.00,0.7,560,2900,26,26,8,8.4
Silk Fabric,9,2000,7.0,60,20.00,0.2,260,400,70,4,6,7.6

3.2 Multiple Attribute Decision-Making for Artistic Photography Material Ranking (MADART)

The Multiple Attribute Decision Making for Artistic Photography Material Ranking (MADART) is a methodical and organized strategy utilized to assess materials based on various attributes, to determine the best appropriate option for particular uses, like artistic photography. This approach entails evaluating each material based on many criteria, such as texture, longevity, color fidelity, reflectivity, expense, ecological footprint, weight, print resolution, drying time, lightfastness, and scratch resistance. MADART enables a thorough comparison by giving weights to attributes depending on their significance, taking into account both quantitative measures and qualitative evaluations. This empowers decision-makers to create well-informed decisions that are in line with the required qualities and effectiveness criteria for materials used in artistic photography. Algorithm 1 presents the MADART algorithm.

Algorithm 1: Multiple Attribute Decision Making for Artistic Photography Material Ranking (MADART)

Input	:	Artistic Photography Material Attributes Dataset
Output	:	Ranking of materials depends on their appropriateness for Artistic photography.
Step 1	:	**Data Preprocessing:**

International Water and Irrigation
Volume 44 Issue 2 (2025)
ISSN: 0334-5807
Pages 249 - 259

		• **Normalize Data:** Using Min-Max Normalization, scale all numerical features to the same range (for example, 0-1).
		• **Handle Missing Data:** If any, utilize imputation techniques like mean imputation.
Step 2	**:**	**Define Weights:**
		• **Feature Selection and Weight Assignment:**
		o Employ InfoGainAttributeEval in conjunction with Ranker search to analyze and rank the significance of each feature.
		o Allocate weights to each feature using their information gain score. Normalize the weights so they sum up to one.
Step 3	**:**	**TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution):**
		• **Determine Ideal and Negative-Ideal Solutions:**
		o **Ideal solution (IS^+):** For attributes where maximum values are superior, the ideal solution is the higher value.
		o **Negative-ideal solution (IS^-):** For attributes where minimum values are superior, the negative-ideal solution is the lower value.
		• **Calculate Euclidean Distance:**
		o Euclidean Distance to ideal solution: $ED_i^+ = \sqrt{\sum(w_j.(x_j - IS_j^+)^2)}$
		o Euclidean Distance to Negative-Ideal Solution: $ED_i^- = \sqrt{\sum(w_j.(x_j - IS_j^-)^2)}$
		• Determine Relative Closeness to Ideal Solution: $TOPSIS_i = \frac{ED_i^-}{ED_i^+ + ED_i^-}$
		i represents the material index, while j represents the attribute index.
Step 4	**:**	**Weighted Sum Model (WSM):**
		• Determine the weighted score for each material by applying the given formula: $$WSM_i = \sum_{j=1}^{n}(w_j * x_j)$$
		The material index is represented by the variable i while the attribute index is represented by the variable j.
Step 5	**:**	Compute the average of the scores derived from TOPSIS and WSM. $$Score_i = \frac{TOPSIS_i + WSM_i}{2}$$
		Where i represents the material index
Step 6	**:**	Arrange all scores in descending order.
Step 7	**:**	The material with the maximal score is regarded as the superior option.

The intricate system architecture illustrated in Figure 1 offers a thorough visual depiction of the MADART algorithm. The architecture visually demonstrates the interrelated elements and their respective roles within the algorithm.

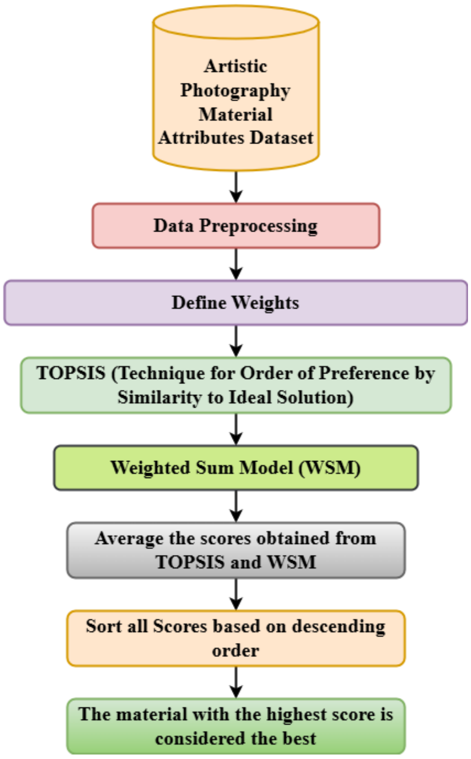


Figure 1: System Architecture of MADART algorithm

3.2.1 Data Preprocessing

Data preprocessing is critical to guaranteeing the dependability and efficacy of the MADART algorithm for picking appropriate materials in creative photography. The dataset contains a variety of features, such as texture (microns), durability (cycles), reproduction of color (Delta E), reflectivity (%), expense ($/sq.ft), impact on the environment (CO_2 kg/sq.ft), weight (g/sq.ft), print resolution (dpi), time to dry (sec), lightfastness (years), and resistance to scratches (rating). To normalize these features for a fair comparison, Min-Max Normalization is used, which scales each feature to a uniform range of 0–1. This normalization technique minimizes biases caused by conflicting measuring units and guarantees that each feature participates evenly in the decision-making procedure.

Missing data must be handled properly to ensure dataset integrity. Mean imputation replaces missing values in any attribute with the average of accessible data points, ensuring that the dataset is correct. Furthermore, category information like material names is converted to numerical counterparts to ensure that the MADART algorithm processes them consistently. This encoding guarantees that each material type appears consistently across the dataset, allowing for reliable comparisons and assessments. In general, data preparation carefully prepares the dataset, laying a firm foundation for the use of the MADART algorithm to discover and rate the most eligible materials for artistic photography using thorough and defined criteria.

3.2.2 Define Weights

Defining weights for each feature is an important phase in the MADART algorithm because it defines the relative relevance of several variables when selecting materials for creative photography. To assign weights, a clever method that combines InfoGainAttributeEval and Ranker search is used. This method examines and ranks attributes using the information acquired, which assesses each attribute's relevance to the process of decision-making. Attributes with more information gain are judged more influential and so awarded higher weights, indicating their stronger impact on the total material selection criterion.

Once features have been ranked, the next step is to normalize their weights so that they amount to one. This normalization standardizes the impact of each property, avoiding biases caused by intrinsically varying scales or ranges of attribute values. By setting these weights, the MADART algorithm could efficiently prioritize features based on their importance while identifying the best material for artistic photography. This systematic approach not only increases the precision and impartiality of the decision-making process but also gives a transparent framework for assessing and comparing materials using their particular qualities in the context of creative photographic needs.

3.2.3 TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution)

TOPSIS is a sophisticated algorithm utilized in the MADART algorithm to rank materials based on their proximity to an optimal solution. TOPSIS, in the context of artistic photography, assists in identifying materials that closely match the necessary attributes by comparing each material to an ideal and a negative-ideal solution. The ideal solution indicates the best values for each feature, whereas the negative ideal solution indicates the worst. This comparison enables a more sophisticated review of how each resource works across all criteria concurrently.

The procedure entails computing each material's Euclidean distance from both the ideal and negative-ideal solutions. TOPSIS computes these distances to assess how close each material is to the ideal solution and how far from the negative ideal solution. Each material's proximity to the ideal solution is then calculated, and this is used to rank them. This process guarantees that materials are thoroughly appraised, taking into account both their advantages and disadvantages. The result is a ranked list of materials, offering a clear and objective basis for picking the most suitable material for artistic photography, guaranteeing optimal performance.

3.2.4 Weighted Sum Model (WSM)

The WSM is a fundamental component of the MADART algorithm, which computes a composite score for each material using the attribute weights allocated to it. This approach generates a weighted score by multiplying every feature value of a material by its associated weight and adding these products across all characteristics. This method guarantees that criteria with higher weights have a bigger impact on the final score, reflecting their relevance in the material selection procedure. The WSM thus provides for a quantitative comparison of materials, offering a clear basis for determining the best option for creative photography.

After computing the weighted scores for all materials, the WSM allows for a comparison study in which items are ordered according to their overall scores. This ranking aids in determining which materials operate more effectively in terms of the defined criteria, offering a solid foundation for decision-making when picking the best material for creative photography. The WSM integrates attribute weights generated from a rigorous review procedure, ensuring that the final ratings appropriately reflect the subtle considerations needed for selecting materials that best fit the aesthetic and technological needs of photography usage.

3.2.5 Final Scoring and Ranking

After using the TOPSIS and WSM to assess each material's qualities, the next step is to calculate the results and rank the materials correspondingly. TOPSIS calculates each material's relative proximity to the ideal solution, taking into account both desired and unfavorable attribute values. By comparing proximity to the ideal answer and distance from the negative ideal solution, TOPSIS gives a thorough assessment that balances advantages and disadvantages across all criteria.

Following the TOPSIS, WSM computes a weighted score for each material by adding the normalized attribute values to their allocated weights. This stage guarantees that traits judged more vital to artistic photography are given more weight in the scoring procedure, reflecting their relative relevance in the ultimate decision-making. Incorporating these methodologies, the final score for each item is calculated by averaging the WSM scores and TOPSIS's relative closeness assessment. This average procedure combines the advantages of both methodologies, providing a solid foundation for evaluating materials from most to least appropriate for creative photographic applications.

4. Experimental Results and Discussions

This section provides experimental findings and discussions about the effectiveness of the MADART algorithm in comparison to the TOPSIS and WSM approaches. The MADART algorithm was developed in Java utilizing the Weka tool, resulting in a reliable environment for processing data and assessment. The MADART algorithm's effectiveness was compared against TOPSIS and WSM utilizing several measures such as Accuracy, Precision, Recall, F1-score, and Geometric Mean.

Accuracy: Accuracy is a metric that quantifies the ratio of successfully identified instances to the total number of instances.

$$\text{Accuracy} = \frac{Number\ of\ correct\ predictions}{Total\ number\ of\ predictions} \tag{1}$$

Precision: Precision is a measure that represents the ratio of correctly predicted positive results to all the positive results anticipated by the model.

$$\text{Precision} = \frac{True\ Positives}{True\ Positives + False\ Positives} \tag{2}$$

Recall: Recall quantifies the ratio of accurately detected positive instances to the total number of actual positive instances, as determined by the model.

$$\text{Recall} = \frac{True\ Positives}{True\ Positives + False\ Negatives} \tag{3}$$

F1-score: The F1-score is the harmonic mean of precision and recall, offering a single metric that balances these concerns.

$$\text{F1-score} = 2 * \frac{Precision * Recall}{Precision + Recall} \tag{4}$$

Geometric Mean: A measure of the overall classifier effectiveness using the geometric average of sensitivity and specificity.

$$\text{Geometric Mean} = \sqrt{Precision * Recall} \tag{5}$$

Table 2 compares accuracy, precision, recall, F1-score, and Geometric Mean for TOPSIS, WSM, and MADART. The MADART algorithm constantly attains superior results across all metrics, suggesting improved effectiveness.

Table 2: Comparison of Performance Metrics

Metrics	Accuracy	Precision	Recall	F1-score	Geometric Mean
TOPSIS	79	76	83	77	80
WSM	83	80	86	81	84
MADART	91	93	92	94	92

Figure 2 depicts the accuracy comparison of TOPSIS, WSM, and MADART. The MADART algorithm is more accurate than both TOPSIS and WSM. This exceptional achievement is owed to MADART's extensive review of many factors, guaranteeing all relevant features are evaluated when picking the best material for artistic photography.

International Water and Irrigation
Volume 44 Issue 2 (2025)
ISSN: 0334-5807
Pages 249 - 259

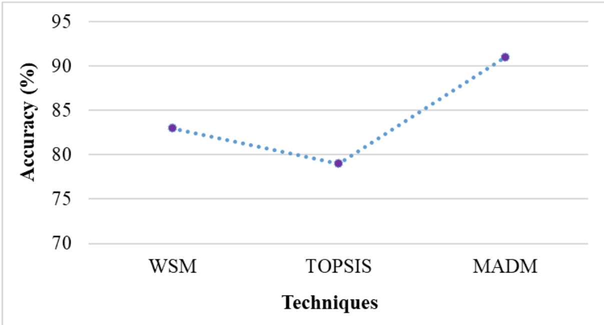


Figure 2: Accuracy Comparison

Figure 3 depicts the precision comparison of TOPSIS, WSM, and MADART. The MADART algorithm is more precise than TOPSIS and WSM. The MADART algorithm's accurate weighing and assessment of features decreases the risk of selecting inferior materials.

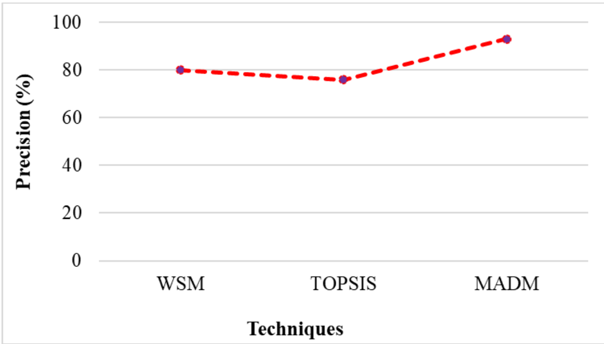


Figure 3: Precision Comparison

Figure 4 shows the recall comparison of TOPSIS, WSM, and MADART. The MADART algorithm outperforms both TOPSIS and WSM in terms of recall. By carefully balancing the significance of each feature, MADART guarantees that crucial materials are not neglected, resulting in improved recall performance.

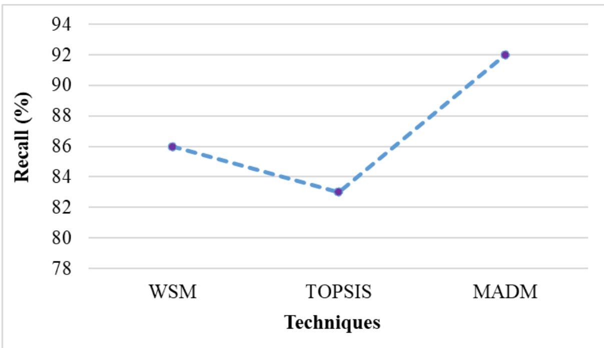


Figure 4: Recall Comparison

Figure 5 shows the F1-score comparison between TOPSIS, WSM, and MADART. The MADART algorithm achieves the highest F1 score of the three approaches. This shows that MADART presents a balanced approach, attaining both high precision and recall, which is critical for precise material selection.

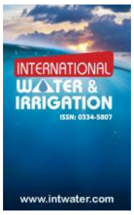
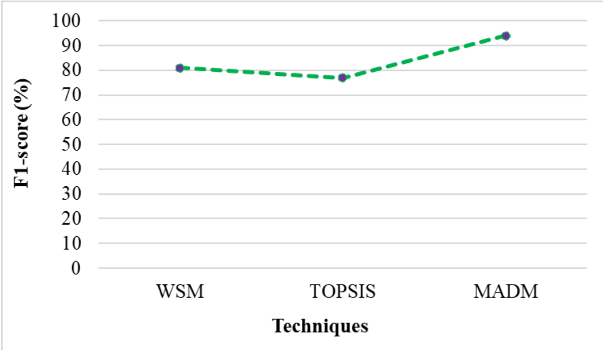



Figure 5: F1-score Comparison

Figure 6 shows the Geometric Mean comparison between TOPSIS, WSM, and MADART. MADART has the greatest GM score of the three approaches, suggesting superior effectiveness in obtaining a balanced evaluation of precision and recall measures. This balanced technique is critical to effectively assessing the appropriateness of materials for creative photography.

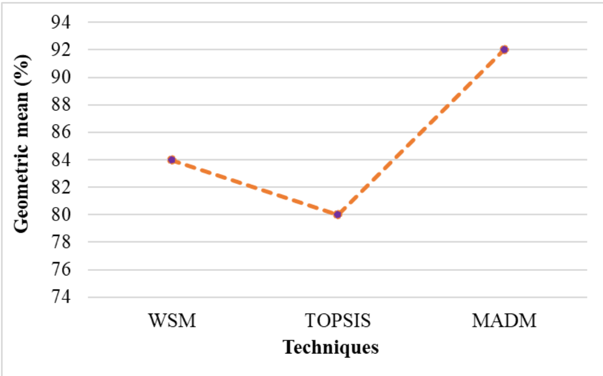


Figure 6: Geometric Mean Comparison

Overall, the MADART algorithm surpasses TOPSIS and WSM in all criteria. Its capacity to rigorously examine materials using many factors guarantees the choice of the most appropriate material for artistic photography, resulting in the finest option for this application.

5. Conclusion and Future Work

This paper introduces and evaluates the MADART algorithm as a reliable way to find the best materials for artistic photography. By methodically examining numerous parameters like texture, durability, color reproduction, and environmental effect, MADART outperformed TOPSIS and WSM. The testing results demonstrated MADART's capability to providing higher accuracy, precision, recall, F1-score and Geometric mean metrics, eventually resulting in best material selection for artistic photography. Future research can examine the use of the MADART algorithm to other areas, like healthcare, economics, and management of the environment, to maximize decision-making procedures depending on numerous criteria. This would increase the MADART algorithm's flexibility and influence across a wide range of fields.

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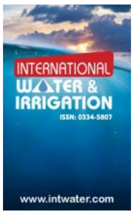

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