

# A DMSS for Sustainable Residential Interior Environmental Design Knowledge Management, Green-Material Ontologies, and Multi-Criteria Optimization

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**Received:** September 4th, 2025 | **Accepted:** December 17th, 2025

## ABSTRACT

This article presents a decision-making support system for sustainable residential interior environmental design that links knowledge management with artificial intelligence-enabled multi-criteria optimization. The architecture integrates data capture, storage, and retrieval for layouts, green-material metrics, energy logs, and resident feedback; a knowledge base unifying organizational memory, best-practice repositories, and semantic ontologies of green materials; a model base with multi-criteria decision models, simulation-derived surrogates, and recommendation routines; dialog management for preference elicitation, constraint specification, and what-if analysis; and output presentation via explainable dashboards plus a feedback-control layer that learns from post-occupancy evaluations. Mixed methods populate and validate the data/knowledge/model bases across diverse housing typologies. Empirical analyses indicated faster green-material adoption, improved layout decisions via designer–resident collaboration, and measurable gains in energy-use intensity and indoor comfort.

## KEYWORDS

Decision-Making Support Systems (DMSS), Knowledge Management, Green-Material Ontologies, Multi-Criteria Decision Analysis (MCDA), Model-Base Management, Dialog Management

## INTRODUCTION

Entering the 21<sup>st</sup> century, humanity faces intensifying pressure on planetary resources as the global population grows (Brown, 2021; Smith & Johnson, 2022). Sustainable development has therefore become a guiding paradigm that balances present needs with those of future generations through coordinated progress across economic, social, and environmental dimensions (Davis & Lee, 2020; Kang & Guerin, 2009). Within this mandate, the residential interior environment—long viewed as both a physical shelter and a carrier of human values—assumes critical importance. Beyond the basic functions of rest and refuge, a thoughtfully designed home can enhance well-being, shape aesthetic sensibilities, and embody occupants’ memories and aspirations (Smith & Johnson, 2022).

Residential interior design is inherently interdisciplinary, drawing on architecture, environmental psychology, materials science, and the arts (Davis & Lee, 2020). Spatial layout (SL) underpins efficient

DOI: 10.4018/IJDSST.397631

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use of area and circulation logic, directly influencing comfort and functionality. Color strategies, informed by color theory and psychological effects, modulate emotional states and behavioral cues. Lighting design—balancing illuminance, color temperature, and control systems—ensures visual clarity and articulates spatial hierarchies through light and shadow. Material selection, spanning natural and synthetic options, carries differentiated footprints in resource consumption, embodied energy, and indoor-air impacts, thereby affecting both environmental sustainability and occupant health (Brown, 2021; Smith & Johnson, 2022).

Under the imperatives of sustainable development, residential interiors must move beyond aesthetics to integrate energy efficiency, environmental protection, and human health into everyday decisions (Kang & Guerin, 2009). Strategies include optimizing layouts to minimize unused volumes and reduce heating and cooling demand (Brown, 2021), employing color schemes that encourage energy-conscious behaviors (Mohsen & Matarneh, 2023), deploying high-efficiency lighting with intelligent controls (Ashour & Rashdan, 2024), and prioritizing renewable, recyclable, and low-toxicity green materials (GMs; El Sayed Salama Mohamed, 2025; Wang & Liu, 2024).

Achieving such integration depends on effective knowledge management. Early work showed how environmentally conscious construction benefited from systematic capture and reuse of lessons learned (Chen et al., 2005). Subsequent frameworks for comprehensive residential projects emphasized codifying best practices (Kärkkäinen, 2014) and structuring knowledge creation processes for design decisions (Lee, 2014; Zhang, 2022). Case studies in Indonesia and Jordan highlighted how firm-level knowledge-sharing cultures enable sustainable innovation (Mohsen & Matarneh, 2023; Utami & Hendarman, 2023), while research on timber construction underscored the role of knowledge pathways in enabling novel material strategies (Riggio et al., 2020).

Digital platforms amplify these effects. Data-driven process optimization leverages digital information management to streamline building-design workflows and enhance performance (Muzi et al., 2022). Smart technologies, including Internet of Things (IoT) integration, support real-time monitoring and are adaptive control responsive to occupants' needs (Ashour & Rashdan, 2024; Wang & Liu, 2024). In the hospitality sector, eco-conscious serviced apartments illustrate how technology-enabled knowledge systems can deliver sustainability alongside user satisfaction (El Sayed Salama Mohamed, 2025).

Leadership and organizational culture further shape outcomes. Green knowledge-oriented leadership aligns strategy with artificial intelligence (AI)-enabled capabilities to drive innovation in small and medium-sized enterprises (Al Koliby et al., 2025), while eco-driven leadership in pharmaceuticals enhances environmental performance via knowledge sharing and shared vision (Alam et al., 2025). Historical analyses of cultural barriers and firm structures show that diagnosing and addressing these factors is essential to mobilize knowledge assets for sustainability (Cabrera & Cabrera, 2005; De Long & Fahey, 2000; Heisig, 2009; Jarvenpaa & Staples, 2000; Teece, 2000;).

Despite these advances, practical gaps persist for residential interiors. Decision support is often fragmented across tools and workflows; few systems jointly operationalize green-material semantics, quantify the influence of layout and daylight on energy and health outcomes, and present explainable recommendations that can be audited and updated over time. Comparative positioning against building information modeling (BIM)-based sustainability tools is limited, and transparency about data, assumptions, and reproducibility is uneven. Addressing these gaps requires a decision-making support system (DMSS) that is knowledge-driven and AI-enabled, capable of codifying best practices and green-material semantics, optimizing layout-material trade-offs under real-world constraints, and explaining recommendations to designers and residents. The DMSS considered here is positioned beyond aesthetics, with explicit targets in energy, health, and resource outcomes and a closed-loop learning process based on post-occupancy feedback.

In response to the above, this study advanced an integrated DMSS and evaluated its relevance through a mixed-methods, multi-regional investigation that linked SL layout rationality, daylight availability, and GM usage to ECI, resource efficiency, indoor air quality (IAQ), and occupant

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