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Perceptions governing the adoption of biomimicry in the UAE construction industry

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Despite the significant potential of biomimicry to advance sustainability in the UAE's rapidly urbanizing construction sector, its widespread adoption is hindered by critical contextual challenges and implementation barriers. Therefore, this study investigates the critical factors shaping stakeholders' perceptions of biomimicry adoption as a sustainable construction strategy in the UAE. Given the region's rapid urban development and environmental challenges, understanding these perceptions is essential for identifying enablers and inhibitors of adoption. A hypothetical model comprising six latent dimensions: knowledge, social, environmental, resource, regulatory, and risk, was empirically tested using Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) based on data collected through a structured survey targeting UAE construction professionals. The results demonstrate that knowledge, regulatory, and risk factors significantly influence stakeholder perceptions and intentions to adopt biomimicry. To complement these insights, the Relative Importance Index (RII) was applied to rank specific indicators within each dimension, offering granular perspectives on stakeholder priorities. The findings emphasize the need for targeted educational programs, policy reforms, and risk mitigation strategies to facilitate biomimicry integration and support the UAE's broader sustainability agenda.

KEYWORDS

perceptions, construction, biomimicry, confirmatory factor analysis (CFA), structural equation modeling (SEM), relative importance index (RII)

1 Introduction

The construction industry is a pivotal sector that sustains numerous other industries and catalyzes socio-economic advancement worldwide, significantly playing a key role in fostering economic growth and long-term development trajectories (Faridi and El-Sayegh, 2006; Giang and Sui Pheng, 2011; Olukolajo et al., 2022; Oluleye et al., 2022). The industry exerts a substantial impact on the Gross Domestic Product (GDP) of nations, with its contributions ranging from 4% to 12% of national GDPs (Goh and Rowlinson, 2013) and employs approximately 7% of the global workforce (Pan and Zhang, 2021). Specifically, within the European Union (EU), the construction industry accounts for approximately 9% of the EU's GDP and secures employment for roughly 18 million people (Norouzi et al., 2021). Henceforth, this sector plays a crucial role in accelerating urbanization and facilitating the development of residential and commercial infrastructure (Aanuoluwapo and Aigbavboa, 2019a; Oluleye et al., 2021; Pero et al., 2017). Moreover, forecasts indicate that the global middle class is anticipated to grow by approximately 160 million individuals annually till 2030 (Kharas, 2017), resulting in a substantial escalation in demand within the construction sector (Joensuu et al., 2020).

However, the construction industry adversely impacts the environment through extensive resource consumption, waste generation, and pollution. It accounts for 40% of global natural resource consumption, generates an estimated 40% of global waste, which is often mismanaged and ecologically harmful, while emitting roughly 33% of the world's harmful pollutants due to its heavy reliance on fossil fuels (Fuertes et al., 2013; Low et al., 2014; Shen and Tam, 2002; van Stijn and Gruis, 2019). Similarly, construction activities produce substantial greenhouse gases (GHGs), volatile organic compounds (VOCs), and chlorofluorocarbons (CFCs), contributing to ozone depletion, climate change, and global warming (Fuertes et al., 2013; González and Navarro, 2006). Other pollution types, including dust, noise, and water contamination from construction runoff, further degrade environmental quality (Low et al., 2014; Wang, 2014). Biodiversity loss is also a critical concern, as construction disrupts ecosystems, alters natural habitats, and causes soil erosion (Fuertes et al., 2013). These considerable adverse effects underscore the critical need for transitioning the construction industry towards the adoption of sustainable practices, such as reducing waste, adopting renewable energy, and implementing eco-friendly designs, to mitigate environmental harm and maximize societal and economic benefits (Asmi et al., 2012; Kibert, 2016; Pearce and Ahn, 2018). These adverse effects, from GHGs and other pollutants, are particularly acute in rapidly urbanizing regions like the United Arab Emirates (UAE), where ambitious development goals intensify the pressure on natural resources and necessitate a transition towards more sustainable practices (Khondaker et al., 2016).

In response to these challenges, a diverse array of professionals, including engineers, architects, innovators, scientists, and sustainability advocates, are increasingly seeking insights beyond conventional boundaries by engaging with solutions inspired by the natural world (Benyus, 2013). This paradigm is encapsulated in the concept of biomimicry, an emerging and innovative field that examines and mimics nature's designs, systems, processes, and strategies to address human problems sustainably (Rao, 2014). For the construction industry, biomimicry offers a transformative approach, providing principles to create buildings and systems that are not only resource-efficient but also resilient and regenerative (Adekunye and Oke, 2023). This involves drawing inspiration from nature to optimize a building's structural, energy, and thermal performance, leading to innovations such as passive ventilation systems modeled on termite mounds, self-cleaning surfaces inspired by the lotus leaf, and strong, lightweight composites that mimic the structure of spider webs or bone (Claggett et al., 2018; Goyes-Balladares et al., 2025; Regassa et al., 2021; Verbrugghe et al., 2023). The relevance of biomimicry to the UAE is underscored by several high-profile projects that demonstrate its potential within the region's unique climatic and developmental context. Some examples include the Al Bahar Towers in Abu Dhabi, inspired by the responsive movement of plants, and Masdar City in Abu Dhabi, inspired by the natural thermoregulation of termite mounds (Alshuhail et al., 2023; Martins-Mourão, 2019). These projects serve as powerful proof-of-concept, showcasing how biomimetic design can deliver energy-efficient and climate-adaptive solutions directly applicable to the UAE market.

However, despite these landmark examples and a growing global interest in the field, the widespread and systematic adoption of biomimicry across the UAE construction sector remains limited (Pugalenthi et al., 2024). This implementation gap is reflected in the academic landscape; as shown in Figure 1, global scholarly output on biomimicry in construction has surged, yet the UAE's contribution remains modest (see Figure 2). While foundational reviews have begun to classify bio-inspired design patterns (Goyes-Balladares et al., 2025) and advocate for their use in climate-sensitive envelopes (Jamei and Vrcelj, 2021), these studies are often conceptual or lack empirical validation within specific regional contexts. Furthermore, they do not sufficiently investigate the complex social, organizational, and perceptual factors that influence the adoption of these principles by industry stakeholders. This research gap highlights the need for a heightened focus on fostering research and development in biomimicry within the region, aligning with its growing emphasis on sustainable construction and innovation-driven economic strategies. Therefore, the primary aim of this research is to assess the multifaceted perceptions governing the adoption of biomimicry in the UAE construction industry. By exploring the underlying factors affecting the stakeholders' perceptions, this research seeks to provide actionable insights that can help bridge the divide between biomimicry's conceptual promise and its practical implementation. The research objectives include (i) the identification of the key factors influencing the adoption of biomimicry within the UAE construction sector, (ii) the verification of content and construct validity using the nominal group technique and Confirmatory Factor Analysis(CFA) (iii) the evaluation of the relationships among the identified factors using the Structural Equation Modeling SEM method to understand their influence on the UAE construction industry stakeholders' overall perception of the adoption and their intention to implement biomimicry principles, (iv) the proposal of recommendations and strategic interventions based on the evaluated perceptions, which will facilitate and enhance the adoption of biomimicry principles within the UAE construction industry.

2 Literature review

2.1 Origins, conceptual definition, and principles of biomimicry

The concept of biomimicry and emulation of natural systems has deep ancient roots, since historically, early humans relied on the natural world for their existence and survival, as evidenced by numerous accounts of Indigenous innovations (Aanuoluwapo and Aigbavboa, 2019a; 2019b; Goyes-Balladares et al., 2025). These innovations spanned several domains, including agriculture and food production, medical and pharmaceutical practices, architectural designs for building envelopes, manufacturing, logistics, and the development of defense systems, which include sensors, armors, and alarm systems (Kshirsagar et al., 2021; Murr, 2015). The natural world is characterized by metamorphoses and

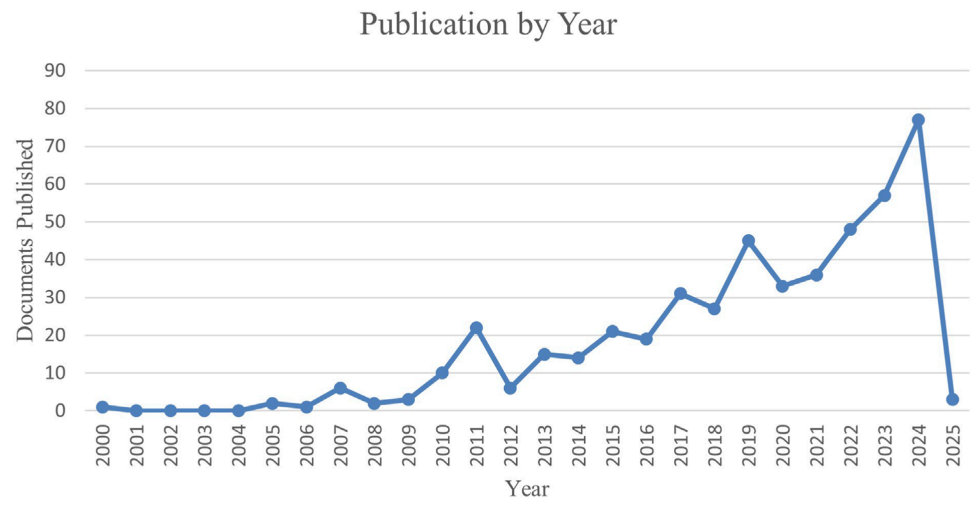

FIGURE 1
Number of publications in the Biomimicry domain. Source: Created by authors (Scopus database).

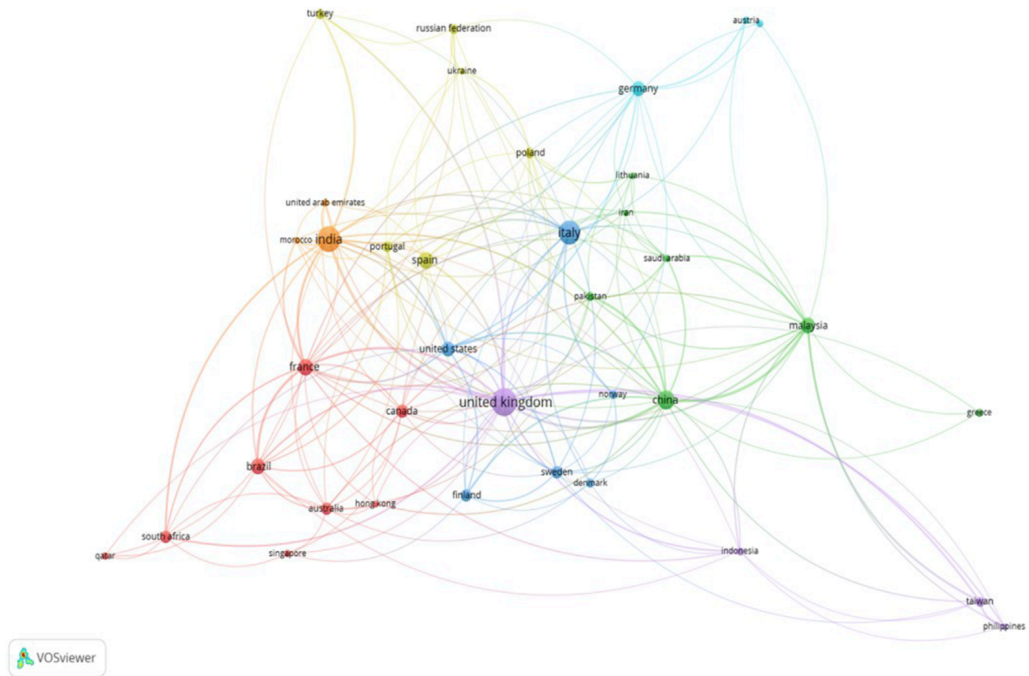

FIGURE 2
Countries publishing in the Biomimicry domain. Source: Created by authors (VOS viewer).

long-term self-sustenance, to effectively meet its own needs and to offer sustainable solutions to the various challenges encountered (Aanuoluwapo and Aigbavboa, 2019b; 2017a; Kshirsagar et al., 2021). With over 3.8 billion years of evolution, nature serves as an exemplary mentor, exemplifying principles of balance and proportion, including efficiency, collaboration, sustainability, and resource management, surpassing technologies developed by humans (Gruber and Imhof, 2017). Through a comprehensive scrutiny of nature, early scientists and innovators have gathered invaluable insights into resource functions and sustainable utilization of resources (Aanuoluwapo and Aigbavboa, 2019b). Prominent instances of nature-inspired innovation include Velcro, derived from the re-attachable characteristics of burrs found on burdock plants, currently referred to as hook-and-loop fasteners, invented by Georges de Mestral (Vincent et al., 2006). Similarly, the architectural design of London's Crystal Palace by Sir Joseph Paxton was influenced by the expansive foliage of the giant Amazonian waterlily (ElDin et al., 2016). Additionally, the design concept for flying machines, notably the ornithopter as proposed by Leonardo da Vinci in 1482, drew inspiration from the flying mechanism of birds, which in turn assisted in the development of the Wright brothers' airplane prototype (Gruber, 2011). Subsequent achievements include various successful free-flight, manned, robotic, and electrically powered ornithopters (Aanuoluwapo and Aigbavboa, 2017a). Furthermore, the Monoplane, also known as Avion III, conceptualized, constructed, and initially piloted by Clément Ader, incorporates principles observed in avian flight (Vincent et al., 2006).

Henceforth, nature is regarded as a formidable repository of knowledge, facilitating the development of groundbreaking solutions to contemporary human challenges through biomimicry (Adekunye and Oke, 2023; Nychka and Chen, 2012). The term "biomimicry" first emerged in 1982 within the title of Connie L. Merrill's doctoral thesis, "Biomimicry of the Dioxygen Active Site in the Copper Proteins Hemocyanin and Cytochrome Oxidase" (Aanuoluwapo and Aigbavboa, 2019a; 2019b; Jamei and Vrcelj, 2021). It gained widespread recognition in 1997 following the publication of a book titled "Biomimicry: Innovation Inspired by Nature," authored by Janine M. Benyus, a biologist and co-founder of the Biomimicry Guild, who is widely acknowledged as a pioneer in this emerging field of study (Aanuoluwapo and Aigbavboa, 2019b; Benyus, 2013). Subsequently, she co-founded the Biomimicry Institute with Schwan, and in 2007, Chris Allen joined the organization to inaugurate "Ask Nature," which is recognized as the world's inaugural digital library, providing natural solutions and inspirations for design practice and research (Jamei and Vrcelj, 2021). Biomimicry is thus characterized as humanity's endeavor to explore and emulate nature's innovations, such as natural selection, photosynthesis, self-repairing, self-assembly, and self-sustaining ecosystems, to address human challenges sustainably (Benyus, 2002). Biomimicry is grounded in the recognition that nature, through over 3.8 billion years of evolution, has developed highly efficient systems and processes that offer sustainable solutions to modern human challenges—prompting advocates to view it as a vast "Research and Development laboratory" from which industries can draw inspiration without compromising environmental integrity or future generations (Aanuoluwapo and Aigbavboa, 2019b; Aanuoluwapo Oguntona and Aigbavboa, 2019; Adekunye and Oke, 2023; Hargroves and Smith, 2006).

Biomimicry is a critical multidisciplinary research field in today's era of rapid climate change and environmental degradation (Aanuoluwapo and Aigbavboa, 2017b), and it integrates experts from diverse domains such as philosophy, computer science, physics, and chemistry, collaborating with biologists, engineers, and architects to develop highly resilient and sustainable solutions (Jamei and Vrcelj, 2021; Knippers and Nickel, 2016). The scholarly discourse presents a variety of terms to denote the practice of learning from and replicating nature, such as biomimicry, biomimetics, bio-inspired design, bionics, bioanalogous design, biomimesis, bioinspiration, and biognosis are frequently used synonymously to articulate this innovative framework (Gamage and Hyde, 2012; Shu et al., 2011; Vincent et al., 2006). However, it is acknowledged that these terms fundamentally converge in their meanings (Aanuoluwapo Oguntona and Aigbavboa, 2019; Aziz and El Sherif, 2016). Biomimicry is derived from the amalgamation of the Greek words bios (life) and mī´mēsis (imitation), encapsulating the concept of 'life imitation' or 'imitation of life' (Aanuoluwapo and Aigbavboa, 2019a; Gamage and Hyde, 2012; Murr, 2015; Nkandu and Alibaba, 2018). This includes the systematic exploration of natural elements and their functional principles to inform innovative design solutions (ElDin et al., 2016; Pawlyn, 2019). Biomimetics, a closely related term, focuses on examining the structure and function of living organisms to inspire material development through reverse engineering (Nachtigall, 2002). In short, biomimicry emphasizes replicating nature's mechanisms to devise sustainable solutions (Badarnah and Kadri, 2015), often using ecological benchmarks to guide the development of vernacular designs that mirror natural forms, processes, and ecosystems (Benyus, 2002). Hence, biomimicry serves as a bridge between technological progress and nature, emphasizing learning from natural models rather than merely extracting resources from them (Adekunye and Oke, 2023). Therefore, the designs that emerge from these processes are not only functional, effective, and efficient but also sustainable and aesthetically appealing. In her seminal work, "Biomimicry: Innovation Inspired by Nature," Janine Benyus articulates nine core principles of nature that serve as the foundational tenets of biomimicry (Adekunye and Oke, 2023; Benyus, 2002; Oguntona and Aigbavboa, 2019). These principles include nature operating on solar energy, nature only expending the energy required, optimizing each form to its function, ensuring complete recyclability, fostering collaboration, depending on diversity, mandating local expertise, nature maintaining self-regulation, and harnessing the strengths inherent in natural limits.

2.2 Biomimicry in the construction industry

In the pursuit of advancing sustainability in the construction sector, a diverse array of methodologies has emerged, ranging from biophilia, ecological economics, the Natural Step, ecological rucksack, eco-efficiency, biomimicry, Building Information Modeling (BIM), cradle-to-cradle, to life-cycle assessment, Value Engineering (VE) and lean construction, each offering unique frameworks to reduce environmental impact and enhance resource efficiency (Hussin et al., 2013; Kibert, 2016). Among these, biomimicry has garnered increasing attention for its innovative potential to align built environments with the regenerative principles of nature, and by comprehensively addressing the triple bottom line of sustainability (Rao, 2014). In contrast, other sustainable construction practices often address only one or two pillars of sustainability, underscoring the holistic approach that biomimicry brings to fostering environmental, social, and economic sustainability within the construction industry (Rao, 2014). Biomimicry offers a transformative potential for sustainable construction by leveraging nature's efficiency and innovative materials to optimize a building's structural, energy, and thermal performance (Goyes-Balladares et al., 2025). This is done by drawing inspiration from the natural world for the design, production, and maintenance of building systems (Adekunye and Oke, 2023), thus enabling architects and engineers to emulate natural processes. Such emulation enhances resource efficiency, reduces environmental impacts, and fosters regenerative solutions, leading to innovative advancements in construction methods (Adekunye and Oke, 2023; Ahamed et al., 2022; Nkandu and Alibaba, 2018; Oguntona and Aigbavboa, 2019).

In fact, the use of biomimetic principles in the construction industry can be traced back to various ancient civilizations. For instance, the Egyptians, Greeks, and Romans integrated aesthetic elements into their architecture by imitating the forms of local flora (Goyes-Balladares et al., 2025). The Goths took this further by employing biomimicry at both the organism and behavioral levels, wherein they designed elegant structures featuring plant-inspired elements such as the rose windows, alongside structural innovations like flying buttresses and ribbed vaults, which were inspired by animal skeletons (Al-Masri et al., 2025). Contemporary research into biomimicry has become a cornerstone for innovation in sustainable construction, with numerous studies investigating nature-inspired solutions to enhance building performance. A systematic review of the field identifies three principal areas of application: the design of intelligent building envelopes, the creation of energy-efficient biomaterials, and the implementation of passive ventilation strategies inspired by natural phenomena (Ergün and Aykal, 2022).

In the realm of structural engineering and material science, researchers draw inspiration from a diverse range of biological structures. For instance, the geometric patterns of spider webs, with their distinct radial and spiral filaments, provide a model for optimizing fiber orientation and load distribution in advanced composite materials (Regassa et al., 2021). Similarly, the hexagonal cell arrangements found in wasp and bee nests are studied to create designs with exceptional structural stability, resilience, and efficiency (Sedira et al., 2023). Furthermore, the nests of swallows offer further insights, demonstrating that the strategic inspiration of naturally available materials can yield structures with superior thermal insulation and mechanical integrity (Bulit and Massoni, 2004). This focus on structural morphology is also seen in analyses of honeycomb-inspired designs, which improve the thermal and energy efficiency of buildings (Pugalenthi et al., 2024), and in studies of coral reefs, which inform the development of new construction materials and structural engineering principles (Chen et al., 2016).

Beyond structural considerations, biomimicry offers powerful strategies for managing a building's internal environment. Nature-inspired building envelopes are being developed to enhance thermal comfort and significantly reduce energy consumption, particularly in regions characterized by hot and arid climates (Elsakksa et al., 2022). Specific case studies have explored dynamic shading systems that function like the opening and closing of flower petals and exterior surfaces that regulate the building's exchange with the environment by mimicking plant stomata (Elsakksa et al., 2022). Passive ventilation is another critical area of advancement, with systems based on the complex morphology of termite mounds proving effective at significantly lowering a building's energy use and carbon footprint (Claggett et al., 2018). Furthermore, advancements in materials science include the development of self-healing composites that emulate the regenerative processes of bone biology, contributing to the durability and lifecycle of building components (Danish et al., 2024). Similarly, self-cleaning materials modeled after the lotus leaf significantly reduce the need for chemical cleaners, while spider silk-inspired composites provide lightweight yet exceptionally durable structural options (Oguntona and Aigbavboa, 2019). These advancements directly tackle critical challenges within the construction sector, including energy efficiency, waste reduction, and material optimization. They embody nature's principles of recycling and reusing resources, ensuring that construction practices not only minimize environmental impact but also enhance sustainability through more effective resource utilization (Nkandu and Alibaba, 2018; Oguntona and Aigbavboa, 2019). When implemented across all phases of construction, biomimicry can yield significant sustainability benefits. For instance, during the design phase, architects can employ strategies inspired by termite mounds, which naturally regulate temperature and airflow. Such bio-inspired approaches can lead to the development of energy-efficient ventilation systems that not only reduce energy consumption but also improve indoor air quality, demonstrating the versatile applications of biomimicry in enhancing environmental sustainability in building designs (Nkandu and Alibaba, 2018). In the construction phase, materials like eco-cement, which mimic natural mineralization processes, provide a low-carbon alternative to traditional cement (Oguntona and Aigbavboa, 2019). At the end of a building's lifecycle, biomimicry can guide modular construction techniques, inspired by nature's adaptability, to make disassembly and material reuse more efficient, thereby supporting circular economy principles (Adekunye and Oke, 2023; Oguntona and Aigbavboa, 2019). By adopting these biomimicry-inspired approaches comprehensively, the construction industry can move toward self-sustaining practices that work in harmony with the environment.

Academic literature has documented the development of several methodologies or thought processes designed to implement the concept of biomimicry within the construction industry (Adekunye and Oke, 2023). Notably, two primary methodologies have been identified: the problem-based (top-down) approach and the solution-based (bottom-up) approach (Elsakksa et al., 2022; Oukati Sadegh et al., 2022). These frameworks guide the application of biomimicry, providing structured pathways either by starting with a specific environmental challenge to find a natural analog (top-down) or by deriving inspiration from natural systems to create innovative solutions independent of a predefined problem (bottom-up). Therefore, in the top-down approach, the aim will be to mimic the natural process that addresses similar challenges to resolve the design problem (Austin et al., 2020). On the other hand, a solution-based (bottom-up) approach will capture a natural phenomenon or scientific knowledge of natural systems to inspire new designs, transforming nature's techniques into technical solutions (Abedanzadeh et al., 2021).

Furthermore, a framework for applying the concept of biomimicry in the construction industry has been developed and functions across three distinct levels: organism, behavior, and ecosystem (Pedersen Zari, 2007; Zari, 2018). At the organism level, the focus is on mimicking nature's form, shape, and structure. The behavior level concentrates on emulating natural processes, and the ecosystem level involves replicating how organisms interact within an ecosystem. At each of these levels, aspects such as appearance and form, materials used, construction methods, functionality, and capabilities are thoroughly examined to integrate biomimetic principles. Also, another framework was developed that focuses on leveraging biomimicry to enhance sustainability in construction projects (Ilieva et al., 2022). This framework is structured on two principal dimensions: the degree to which nature's attributes are mimicked in relation to sustainability, and whether the biomimetic approach is fixed or adaptable. Understanding the full potential of biomimicry can be achieved by applying this framework to existing biomimetic construction projects to assess its effectiveness and adaptability (Othmani et al., 2022).

Contemporary architecture provides numerous examples of built projects where biomimetic principles have been successfully implemented to solve complex engineering and environmental problems (Goyes-Balladares et al., 2025). These applications range from climate control and energy management to innovations in structural systems and material efficiency. One of the most prominent areas of application is in building thermoregulation and ventilation. The Eastgate Centre in Zimbabwe, for instance, employs a passive cooling system modeled on the self-regulating thermal dynamics of termite mounds, a design that eliminates the need for conventional air conditioning and dramatically lowers energy consumption (Verbrugghe et al., 2023). On a larger scale, the Sahara Forest Project tackles the challenge of desertification by utilizing saltwater-cooled greenhouses that mimic the fog-harvesting shell of the Namib Desert beetle (Othmani et al., 2022). Through the evaporation of seawater to cool and humidify arid air, and then the condensation of that moisture on cool surfaces, the system generates its own freshwater for year-round irrigation, thus enabling restorative land use in extreme desert climates (Othmani et al., 2022; Yuan et al., 2017). Similarly, the Gherkin Tower in London employs a dual biomimetic strategy, emulating the Venus' flower basket sponge's lattice exoskeleton for structural strength and material efficiency against wind, while also utilizing helical atria to create a natural ventilation system analogous to a respiratory organ (Goyes-Balladares et al., 2025; Küçük and Arslan, 2020; Othmani et al., 2022). Pushing biological integration further, Germany's BIQ House incorporates a bioactive facade with photobioreactors that cultivate microalgae. This living system replicates the metabolic processes of aquatic ecosystems, capturing carbon dioxide and converting solar energy into biomass (Biloria and Thakkar, 2020). Biomimicry has also driven significant advancements in structural design and adaptive facades. The Eden Project in the UK features large-scale biomes whose lightweight, modular structure emulates the material efficiency and geometry of soap bubbles and pollen grains, resulting in a highly efficient and topographically adaptable enclosure (AlAli et al., 2023; Othmani et al., 2022; Verbrugghe et al., 2023). In Singapore, the Esplanade Theatre addresses its tropical and hot climate with an adaptive sun-shading system modeled on the spiky exterior of the durian fruit, a design that strategically filters sunlight to reduce solar heat gain, resulting in a 55% decrease in artificial lighting needs and a significant reduction in overall energy consumption (Radwan and Osama, 2016). On a similar note, in South Korea, the One Ocean Pavilion showcases a kinetic facade inspired by the hinge-free, elastic movements of plant life. Its system of flexible, reinforced polymer slats can be manipulated to create dynamic patterns, offer responsive shading, and adapt to weather conditions, serving as a prime example of integrating nature's functional mechanisms into architecture (Goyes-Balladares et al., 2025).

2.3 Factors affecting the adoption of biomimicry in construction

There are multifaceted factors that influence the adoption of biomimicry within the construction industry. Table 1 defines the various dimensions impacting stakeholders' perceptions and decisions regarding biomimicry adoption, structured across distinct categories including Knowledge, Social, Environmental, Resource, Regulatory, and Risk factors. Each category comprises several indicators that provide an understanding of the elements affecting biomimicry's integration into construction practices. The allocation of observed variables (indicators) to their respective latent constructs reflects the integration of theoretical perspectives from existing biomimicry and sustainability research. This exploration of the dimensions and indicators aims to provide a foundation for understanding how they collectively influence the adoption of biomimicry in the construction sector. The indicators, supported by scholarly references, underscore the critical areas of focus for stakeholders considering biomimicry's potential to revolutionize sustainable construction practices.

2.4 Biomimicry in the UAE construction industry

The UAE's application of biomimicry in construction for sustainability aligns closely with global practices, despite the challenges posed by its harsh climate. Notable instances such as the Masdar Institute and Al Bahar Towers serve as exemplary demonstrations of biomimicry within the UAE's construction industry. According to Martins-Mourão (2019) Masdar City has implemented a mandate to employ passive architectural solutions that reduce local temperatures by 10 °C–15 °C relative to Abu Dhabi city. This cooling effect has been achieved through passive cooling techniques inspired by the natural temperature regulation found in termite mounds. Specifically, the Masdar Institute of Science and Technology has significantly reduced reliance on HVAC systems for cooling its buildings by adopting biomimetic strategies that replicate the internal temperature regulation of termite mounds, complemented by solar shades and effective ventilation strategies. Subsequently, Alshuhail et al. (2023) conducted a comparative case study in the UAE featuring two structurally identical models in terms of internal dimensions and area: a Regular Block (RB) representing conventional construction, and a Termite Block Model (TM), inspired by termite mounds and incorporating principles of natural ventilation and thermoregulation. Infrared thermography was employed for over a year to assess thermal performance, utilizing metrics such as the Decrement Factor (DF), Temperature Difference Ratio (TDR), and Time Lag (Tlg). The findings demonstrated that the biomimicry of termite mound shapes could significantly enhance building envelope design to reduce energy consumption and maintain comfortable indoor temperatures. Notably, the TM model showed superior thermal performance, achieving an average time lag of 3 hours and thus enhancing heat absorption compared to the thermally reflective RB model.

In the Al Bahar Towers in Abu Dhabi, shading elements were engineered to mimic the movements of plants in response to the sun's direction (Bahar, 2017). The shading system features 1,000 triangular panels that dynamically adjust to solar movement by opening and closing throughout the day to modulate sunlight exposure and reduce heat gain, while closing at night to conserve energy. Inspired by biomimicry, this design effectively regulates natural light, thereby decreasing dependence on artificial lighting

TABLE 1 Dimensions affecting the adoption of biomimicry.

Dimension	Code	Indicators	Indicator description	References
Knowledge Factor (KNW)	KNW1	Awareness of biomimicry	Clarity in the conceptualization of biomimicry approaches within the construction sector	Aanuoluwapo and Aigbavboa (2019b), Aanuoluwapo Oguntona and Aigbavboa (2019), Gamage and Hyde (2012), Silva et al. (2024)
	KNW2	Professional knowledge	Level of professional expertise available in biomimicry within the construction industry	Aanuoluwapo and Aigbavboa (2019b), Aanuoluwapo Oguntona and Aigbavboa (2019), Jones et al. (2024), Silva et al. (2024)
	KNW3	Biomimicry education	Inclusion of biomimicry topics in university curricula for construction and design, along with training programs and enhanced awareness among professionals and stakeholders in construction	Aanuoluwapo and Aigbavboa (2019b), Aanuoluwapo Oguntona and Aigbavboa (2019), Adekunye and Oke (2024), Oguntona and Aigbavboa (2019), Silva et al. (2024)
	KNW4	Presence of practical examples	Availability of real-life examples demonstrating the application of biomimicry in construction	Silva et al. (2024)
	KNW5	Understanding of ecosystem complexities	Degree to which the complexity of natural ecosystems is understood within the context of biomimicry applications	Gamage and Hyde (2012)
Social Factor (SOC)	SOC1	Impact on occupant health and productivity	Nature-inspired designs improve air and water quality, contributing to healthier living environments, thus, improving occupant comfort and wellbeing, leading to higher productivity	Aanuoluwapo and Aigbavboa (2019a)
	SOC2	Aesthetic impact of biomimicry	Nature-inspired designs result in visually appealing structures (aesthetic value)	Aanuoluwapo and Aigbavboa (2019a)
	SOC3	Employment opportunities from biomimicry	Expands markets for green products and creates new business and employment opportunities in sustainable construction	Aanuoluwapo and Aigbavboa (2019a)
	SOC4	Market condition	Level of client demand for biomimicry in construction projects	Aanuoluwapo and Aigbavboa (2019b), Aanuoluwapo Oguntona and Aigbavboa (2019), Silva et al. (2024)
	SOC5	Collaboration in biomimicry projects	Performance and effectiveness of multidisciplinary collaboration in projects involving biomimicry	Aanuoluwapo and Aigbavboa (2019b), Aanuoluwapo Oguntona and Aigbavboa (2019), Adekunye and Oke (2024)

(Continued on the following page)

TABLE 1 (*Continued*) Dimensions affecting the adoption of biomimicry.

Dimension	Code	Indicators	Indicator description	References
Environmental Factor (ENV)	ENV1	Energy management through biomimicry	Biomimetic designs reduce energy consumption through natural cooling, insulation, and energy-saving strategies (e.g., Eastgate Centre, Zimbabwe)	Aanuoluwapo and Aigbavboa (2019a), Jones et al. (2024), Pugalenthi et al. (2024)
	ENV2	Resource management and waste reduction	Efficient use of resources and promotion of renewable materials, reducing waste and mimicking natural recycling processes	Aanuoluwapo and Aigbavboa (2019a), Jones et al. (2024), Pugalenthi et al. (2024)
	ENV3	Water management innovations from biomimicry	Biomimetic solutions for water harvesting, like the Namib Desert beetle-inspired surfaces, address urban water scarcity	Aanuoluwapo and Aigbavboa (2019a), Oguntona and Aigbavboa (2017), Pugalenthi et al. (2024)
Resource Factor (RES)	RES1	Biomimicry resource and material availability	Availability and accessibility of databases, information resources, and suitable materials are essential for facilitating biomimicry applications in construction	Aanuoluwapo and Aigbavboa (2019b), Aanuoluwapo Oguntona and Aigbavboa (2019), Silva et al. (2024)
	RES2	Technology innovation	Creating nature-inspired technologies like self-cleaning, self-healing, or energy-saving materials	Oguntona and Aigbavboa. (2017)
	RES3	Structural efficiency	Nature-inspired designs, like the Eiffel Tower modeled after femur bones, provide high strength-to-weight ratios for lighter, stronger structures	Aanuoluwapo and Aigbavboa (2019a), Oguntona and Aigbavboa (2017), Pugalenthi et al. (2024)
	RES4	Resilience & adaptability	Buildings designed to withstand environmental challenges (e.g., self-healing materials, climate adaptation)	Oguntona and Aigbavboa (2017), Pugalenthi et al. (2024)
Regulatory Factor (REG)	REG1	Policy and educational support for biomimicry	Promoting biomimicry through policy and educational integration	Jones et al. (2024), Oguntona and Aigbavboa (2017)
	REG2	Construction codes involving biomimicry	Inclusion of biomimicry principles within the building codes that govern construction	Aanuoluwapo and Aigbavboa (2019b), Aanuoluwapo Oguntona and Aigbavboa (2019), Silva et al. (2024)
	REG3	Governmental support for biomimicry	Level of government support, including regulations and policies, which facilitate the adoption of biomimicry in construction	Aanuoluwapo and Aigbavboa (2019b), Aanuoluwapo Oguntona and Aigbavboa (2019), Adekunye and Oke (2024), Gamage and Hyde (2012), Silva et al. (2024)

(Continued on the following page)

TABLE 1 (*Continued*) Dimensions affecting the adoption of biomimicry.

Dimension	Code	Indicators	Indicator description	References
Risk Factor (RSK)	RSK1	Cost implications of biomimicry adoption	Financial considerations associated with adopting biomimicry in construction	Aanuoluwapo and Aigbavboa (2019b), Aanuoluwapo Oguntona and Aigbavboa (2019), Jones et al. (2024), Silva et al. (2024)
	RSK2	Performance efficiency and effectiveness uncertainty	Uncertainties related to the performance and efficiency of biomimetic solutions in construction	Aanuoluwapo and Aigbavboa (2019b), Aanuoluwapo Oguntona and Aigbavboa (2019)
	RSK3	Time allocation for biomimicry implementation	Time required to implement biomimicry solutions within construction projects	Aanuoluwapo and Aigbavboa (2019b), Aanuoluwapo Oguntona and Aigbavboa. (2019), Jones et al. (2024), Silva et al. (2024)
	RSK4	Industry structure	Structural aspects of the construction industry, such as fragmentation and capital costs, may influence biomimicry adoption	Adekunye and Oke. 2024, Jones et al. (2024)

and ventilation, and ultimately enhancing building energy efficiency. Various studies have been undertaken to assess the potential of biomimicry in boosting energy efficiency and sustainability within the UAE. For instance, a study by Aburaed et al. (2022) proposed a petrol station design inspired by the Ghaf tree, the national tree of the UAE, renowned for its resilience in harsh environments. This design incorporated photovoltaic solar panels and smart materials such as chromogenic glazing, which can overcome the challenges associated with electrical connections in remote locations. The study demonstrated that integrating biomimicry with dynamic smart glazing materials could not only achieve energy efficiency but also enhance sustainability and cultural relevance within architectural designs. Further research conducted by Al-Saffar (2018) utilized Ecotect simulation software to apply biomimetic strategies inspired by butterflies to a residential unit in Dubai. This research assessed the impact of these strategies on thermal comfort and energy efficiency. The findings underscored the capacity of biomimicry to improve sustainable design solutions, providing architects with innovative methods to tackle the unique climatic challenges of the UAE.

While the UAE has demonstrated a promising engagement with biomimicry in the construction sector, widespread and systematic adoption remains limited across the broader industry landscape. This underutilization underscores a critical opportunity to explore the underlying factors influencing the adoption of biomimetic principles in architectural and construction practices. Although existing literature emphasizes the sustainability and energy-efficiency gains associated with biomimicry, its potential remains largely untapped in the UAE context, especially from the lens of stakeholder perception. Recent bibliometric and thematic reviews, such as that of Goyes-Balladares et al. (2025), provide a foundational classification of biomimicry in architecture by structuring design patterns at the organism, behavioral, and ecosystem levels. Such taxonomies are invaluable in systematizing bio-inspired innovation, but are predominantly conceptual and lack empirical validation within region-specific contexts. Similarly, Jamei and Vrcelj (2021) offer a broad yet insightful review of biomimicry applications in architecture and structural engineering, advocating for its integration into climate-sensitive, energy-efficient building envelopes and structural systems. However, the study does not investigate the social perceptions or organizational dynamics that influence adoption. Further, Verbrugghe et al. (2023) identify a persistent fragmentation in the field of Biomimicry In Architecture (BIA), highlighting inconsistent definitions, methodologies, and classifications that challenge cohesive implementation across built environment disciplines. Therefore, addressing this fragmentation necessitates localized empirical inquiry.

Moreover, AlAli et al. (2024) emphasize the strategic potential of biomimicry and biophilic design in reimagining laboratory environments as living, sustainable systems. Their Nature-Inspired & Living Laboratory (NILL 1.0™) assessment tool demonstrates a forward-looking, systemic approach to design, yet it remains limited in its transferability to mainstream construction practices and general building typologies. Complementing this, AlAli et al. (2023) underscore the conceptual novelty of biomimicry within construction and civil engineering, yet reveal a significant implementation gap, particularly in emerging markets such as the UAE (Pugalenthi et al., 2024). Building upon these insights and addressing the evident gaps, this research aims to empirically examine the perceptual and contextual factors influencing the adoption of biomimicry in the UAE construction sector. By focusing on stakeholder perceptions and leveraging a structured framework informed by prior classifications and thematic reviews, this study seeks to bridge the divide between conceptual promise and practical uptake, ultimately facilitating a broader, evidence-based integration of biomimicry in the UAE's built environment.

3 Research methodology

The research methodology undertaken is designed to identify the factors influencing the adoption of biomimicry in the UAE construction industry. The methodological process consists of sequential phases, as illustrated in Figure 3. These include: (i) theoretical framework development; (ii) instrument design and validation; (iii) data collection; and (iv) data analysis.

3.1 Theoretical framework development

The first phase entailed the identification of the research problem and the conceptualization of the latent dimensions influencing biomimicry adoption. An extensive literature review was conducted to establish a theoretical framework grounded in prior empirical and conceptual studies. This review led to the identification of six critical dimensions relevant to the UAE construction context, including: Knowledge, Social, Environmental, Resource, Regulatory, and Risk, each of which was operationalized through a set of indicators derived from scholarly literature. These indicators were subsequently used to construct a survey instrument for empirical data collection. Table 1 outlines the conceptual foundations of these dimensions and presents the corresponding indicators used to measure each construct. This literature-informed structure provided the basis for subsequent CFA to test the measurement model's validity.

3.2 Instrument design and expert validation

Upon the completion of the literature review, a structured questionnaire was developed to empirically investigate the proposed latent constructs. To ensure the quality and relevance of the survey instrument, a pilot test was conducted prior to full-scale data collection. This step aligns with the best practices established in prior empirical research, which emphasize the importance of pre-testing survey tools to confirm their viability and content appropriateness. In this study, the Nominal Group Technique (NGT), commonly recognized as a structured expert consultation method, was employed to support the refinement process. Under this technique, a panel of experts was individually invited to evaluate each survey item, offering their assessments independently to avoid groupthink or dominance bias (Powell and Single, 1996). Their evaluations focused on the clarity, relevance, and representativeness of each indicator in relation to the construct it was intended to measure. This approach enhanced the instrument's content validity and ensured that the selected indicators were contextually grounded in the UAE construction industry. Therefore, to ensure content validity, the initial draft of the survey was reviewed by a panel of 8 UAE-based experts using the nominal group technique. This panel comprised seven senior industry practitioners and one academic, each with between 10 and 25 years of experience in the construction industry, working as executive and general managers, senior project managers with substantial expertise in sustainability. Each item was evaluated on a five-point Likert scale for clarity and relevance. As a result, a refined set of 24 indicators was retained for final analysis. The expert panel's composition is summarized in Table 2 below and reflects a high degree of professional diversity and domain expertise.

3.3 Sampling design and data collection

The target population comprised professionals actively engaged in the UAE construction sector, including individuals working in consultancy, contracting, real estate development, governmental agencies, and academia. A snowball sampling technique was employed to identify and recruit participants; whereby initial respondents were encouraged to forward the survey to qualified peers within their professional networks. The refined survey instrument was pilot tested for clarity, relevance, and reliability with a small sub-sample of industry experts. Following minor revisions, the final version was administered online via Google Forms. Data collection was conducted over a 3-week period, during which the survey link was circulated through email invitations and professional networking platforms such as LinkedIn. A total of 110 responses were received, of which 90 fully completed responses were retained for analysis following a completeness screening. The survey collected detailed demographic information such as educational background, professional role, years of experience, and types of projects managed. This enabled a richer interpretation of stakeholder perspectives across a diverse respondent base. Furthermore, the respondents provided their perceptions of the 24 indicators using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree), thereby facilitating a comprehensive assessment of the determinants influencing the adoption of biomimicry in the UAE construction industry. To prepare the dataset for analysis, the Likert-scale responses were systematically converted to corresponding numerical values, and all incomplete entries were omitted. This refinement process resulted in a final sample of 90 fully completed responses out of the initial 110, thereby ensuring the analytical rigor and reliability of the data.

3.4 Data analysis techniques

After the completion of data collection, a series of rigorous statistical procedures was conducted using SAS Studio to ensure the robustness and validity of the findings. Initially, internal consistency was assessed using Cronbach's alpha (α), a widely accepted reliability coefficient known for its simplicity and applicability in Likert-scale-based instruments (Bland and Altman, 1997; Hair et al., 2014). Its extensive use in social science research and compatibility with ordinal data make it a well-suited metric for evaluating the coherence of responses within each construct in the present study. To further establish convergent validity, two additional measures were applied: Composite Reliability (CR) and Average Variance Extracted (AVE). CR offers a more precise estimation of internal consistency as compared to Cronbach's alpha (α) by accounting for the varying loadings of individual items (Hair et al., 2014; Henseler et al., 2009), while AVE quantifies the proportion of variance captured by the construct in relation to the variance attributable to measurement error (Awad et al., 2020). These metrics

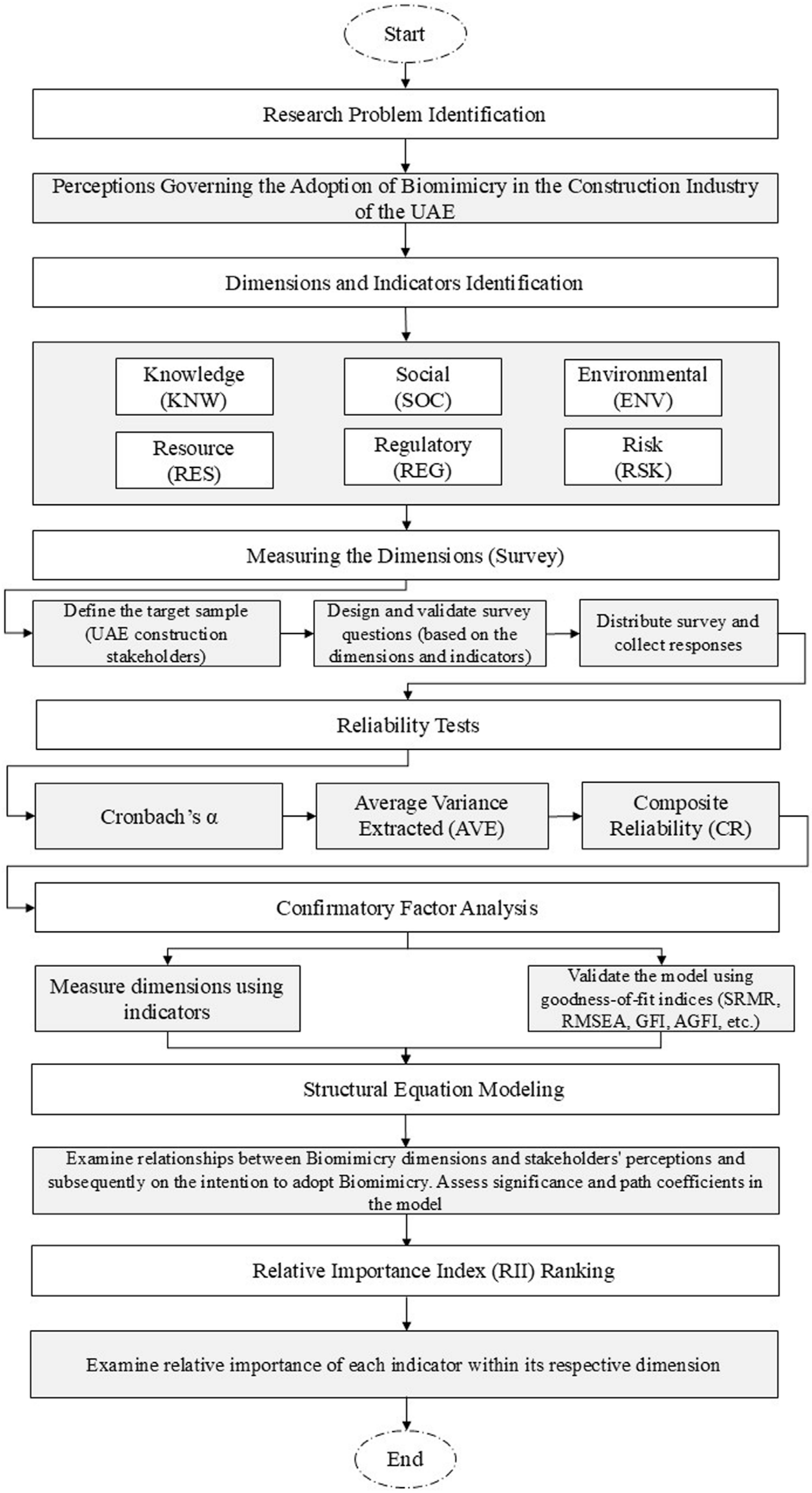

FIGURE 3
Methodology Flowchart.

are particularly relevant in the context of SEM and contribute to the validation of the underlying constructs (Bacon et al., 1995; Farrell, 2010).

Upon confirming reliability and convergent validity, a first-order CFA was conducted to assess the measurement model comprising the six latent constructs. CFA was selected over alternative

TABLE 2 Expert panel details.

No.	Affiliation	Core business	Experience	Terminal degree	Years of experience in sustainability
1	Founder	A/E	10–20	Doctorate	5–10
2	Executive manager	Main contractor	>25	Bachelor's	5–10
3	Senior projects manager	Main contractor	>20	Master's	10–20
4	Professor, full-time	Academia	>25	Doctorate	10–20
5	Partner	A/E	>25	Master's	10–20
6	General manager	Development company	10–20	Master's	5–10
7	Project manager	A/E	10–20	Bachelor's	5–10
8	General manager	A/E	10–20 Years	Bachelor's	10–20

approaches such as Exploratory Factor Analysis or Item Response Theory, due to its strength in testing theory-driven models and assessing model fit (Alherimi et al., 2024; Hox, 2021). Each construct was measured by its corresponding indicators (Table 1), and model identification was ensured by fixing one loading per factor to unity. Through CFA, the study validated the hypothesized measurement model by examining standard parameter estimates, factor loadings, and fit indices such as the Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), Goodness-of-Fit Index (GFI), and Comparative Fit Index (CFI). Where necessary, modification indices were reviewed to identify areas for model refinement. Thus, CFA was used to statistically validate whether the hypothesized factor structure, consisting of six dimensions, was supported by the empirical data.

Following the validation of the measurement model, SEM was employed as a comprehensive analytical approach that combines both factor analysis and path analysis. This method enabled the simultaneous assessment of the measurement properties of the latent constructs and the hypothesized causal relationships between them (Cheung et al., 2024). SEM was particularly instrumental in evaluating the influence of the six independent dimensions on the two key outcome variables: stakeholders' perceptions of biomimicry and their intention to adopt such practices. The structural model, developed based on the theoretical framework and illustrated in Figure 4, was analyzed using SAS Studio via covariance structure modeling. This involved assessing path coefficients, standard errors, and p-values to determine the statistical significance of each relationship. Model fit was evaluated using the same set of goodness-of-fit indices applied during CFA, ensuring consistency in assessing the adequacy of the structural model. To test the influence of each dimension on stakeholders' perceptions of biomimicry adoption, the following hypotheses were formulated.

H1: Knowledge dimension has a significant impact on the perception of stakeholders towards biomimicry in the UAE construction industry.

H2: Social dimension has a significant impact on the perception of stakeholders towards biomimicry in the UAE construction industry.

H3: Environmental dimension has a significant impact on the perception of stakeholders towards biomimicry in the UAE construction industry.

H4: Resource dimension has a significant impact on the perception of stakeholders towards biomimicry in the UAE construction industry.

H5: Regulatory dimension has a significant impact on the perception of stakeholders towards biomimicry in the UAE construction industry.

H6: Risk dimension has a significant impact on the perception of stakeholders towards biomimicry in the UAE construction industry.

In addition to CFA and SEM, which primarily assess the validity of the measurement model and the structural relationships among latent constructs, the Relative Importance Index (RII) was employed to rank and prioritize individual indicators based on stakeholder responses. The RII serves as a complementary analytical tool that quantifies the perceived importance of each indicator on a standardized scale, thus offering a more granular perspective on the data. While CFA and SEM provide insights into the statistical significance and strength of relationships at the latent construct level, RII enhances interpretability by identifying which specific items within each construct are deemed most influential by respondents. This dual-layered approach strengthens the overall analysis by not only validating the theoretical model statistically but also aligning it with stakeholder priorities in practice.

Finally, based on the analytical outcomes, the study proceeded with an in-depth discussion of results, followed by the synthesis of key findings, conclusions, and practical recommendations to support biomimicry integration in the UAE construction industry.

4 Results and discussion

The analysis followed a multi-step process: (i) descriptive analysis of the respondents' demographics; (ii) assessment of reliability and construct validity using Cronbach's alpha, CR, and

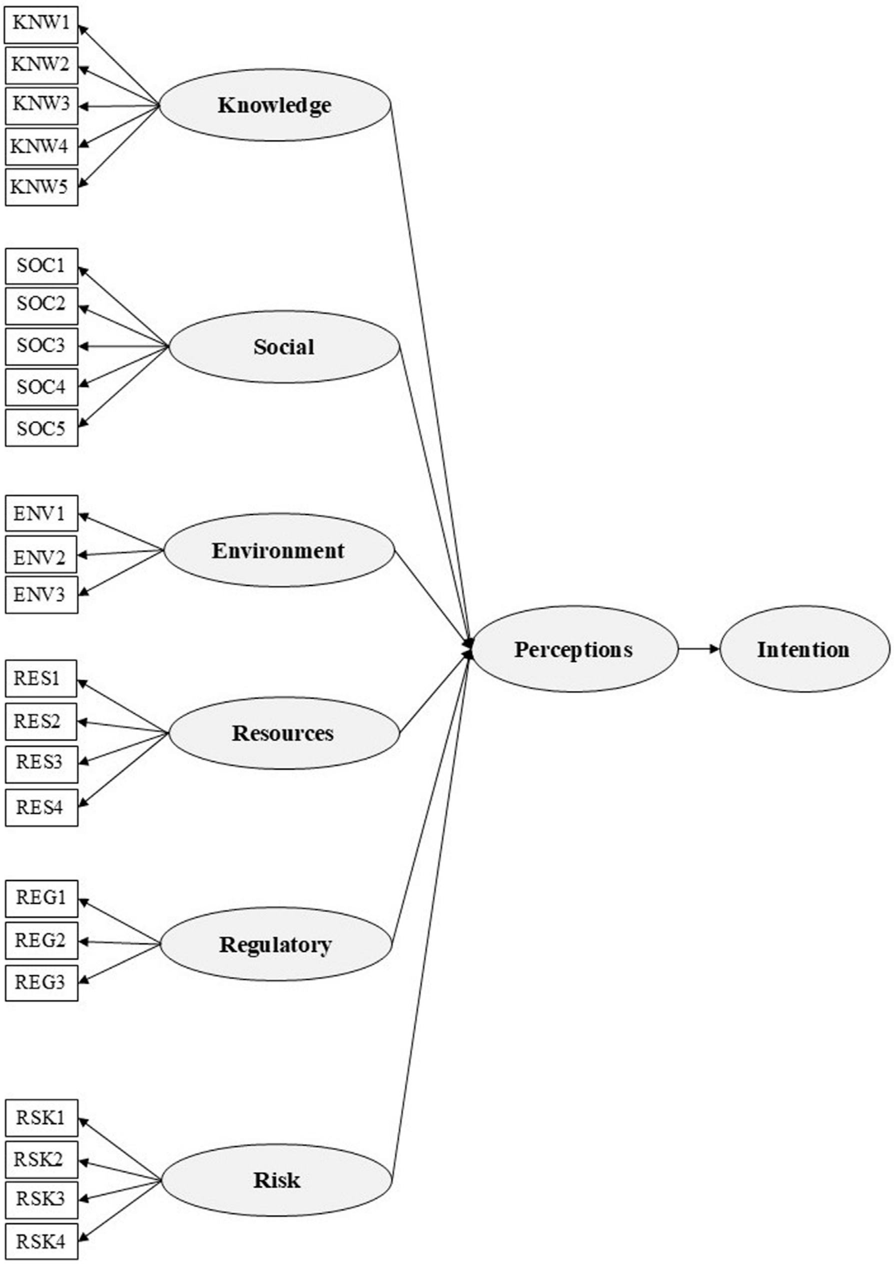

FIGURE 4
SEM Model for stakeholders' perceptions governing the adoption of biomimicry in the UAE.

AVE; (iii) validation of the measurement model through CFA; (iv) hypothesis testing via SEM to explore causal relationships; and (v) prioritization of indicators using the Relative Importance Index (RII).

4.1 Respondents' demographics

The demographics of the respondents, as outlined in Table 3, offer a detailed breakdown that is important in understanding the diverse backgrounds and extensive expertise present within the sample group, which is crucial for the generalizability of the study findings to the UAE construction industry. The distribution of years of experience among the respondents highlights a broad range of expertise in the construction sector. A significant portion (26.7%) of the participants have between 0 and 5 years of experience, indicating a substantial involvement of early-career professionals. Experienced professionals with over 20 years in the field also represent a considerable segment (24.4%), suggesting that the responses encompass insights from both emerging and established perspectives within the construction community. The educational qualifications of the respondents are predominantly bachelor's (46.7%) and master's degrees (46.7%), with a smaller proportion holding doctorate degrees (6.7%). This educational distribution

TABLE 3 Respondents' demographics.

No	Demographic information	%
1	Years of experience	
	0–5	26.7
	5–10	17.8
	10–15	22.2
	15–20	8.90
	>20	24.4
2	Education background	
	Bachelor's degree	46.7
	Master's degree	46.7
	Doctorate degree	6.70
3	Core business	
	Clients	18.9
	Consultants	26.7
	Main contractors	22.2
	Government employees	23.3
	Green consultant	2.20
	Higher education – college of engineering	6.67
4	Average cost of undertaken projects (aed)	
	<50 Million	23.3
	50–200 Million	38.9
	>200 Million	37.8
5	Projects' Type[a]	
	Industrial	20.0
	Infrastructure	32.2
	Commercial	68.9
	Residential	80.0

[a]Respondents were given the option to select multiple project types.

indicates a highly educated workforce capable of understanding advanced construction techniques such as biomimicry.

The study features a diverse stakeholder composition, with consultants (26.7%), main contractors (22.2%), and government employees (23.3%) representing the core business activities. This heterogeneity, further enriched by clients, developers, green consultants, and academic professionals, provides a well-rounded perspective on biomimicry adoption in the industry. The survey indicates that respondents predominantly manage projects valued between 50 and 200 million AED (38.9%), suggesting involvement in significant capital initiatives where biomimicry could substantially enhance sustainability. The diversity in project types, with a notable percentage in residential (80.0%) and commercial sectors (68.9%), highlights the broad applicability of the survey findings. In summary, the demographic data ensures that the insights gained are reflective of a cross-section of the UAE construction industry, encompassing varied levels of experience, educational backgrounds, business focuses, project scales, and types.

4.2 Reliability and construct validity

To ensure the robustness of the subsequent CFA and SEM analyses, the reliability and construct validity of the measurement model were assessed. As shown in Table 4, internal consistency was examined using Cronbach's alpha, Composite Reliability (CR), and Average Variance Extracted (AVE). All constructs reported Cronbach's alpha values above the accepted threshold of 0.7 (Henseler et al., 2009), indicating strong internal consistency. Similarly, CR values for all dimensions exceeded the acceptable 0.7 benchmark (Yusoff et al., 2020), further confirming the reliability of the latent constructs. Convergent validity was supported by AVE values, with most constructs surpassing the widely acceptable 0.5 criterion (Santos and Cirillo, 2023; Yusoff et al., 2020). These results confirm that the observed variables reliably reflect their respective latent dimensions and justify proceeding with confirmatory factor analysis.

4.3 Confirmatory factor analysis (CFA)

Confirmatory Factor Analysis (CFA) was conducted using SAS Studio to validate the measurement model prior to structural modeling. The analysis examined the covariance structure among the six latent dimensions: Knowledge, Social, Environmental, Resource, Regulatory, and Risk. Model fit was evaluated using various goodness-of-fit indices, including the Chi-square statistic, SRMR, GFI, RMSEA, and CFI. Additionally, Table 4 details the standardized parameter estimates from CFA and the subsequent p-values for each indicator. It is evident that all path coefficients achieve statistical significance, as indicated by the p-values being less than 0.05. Moreover, the majority of the CFA standardized parameter estimates notably exceed the threshold of 0.6, reflecting strong and meaningful loadings on their respective latent factors. This high level of factor loadings highlights the considerable influence of each manifest variable on its corresponding latent construct, further reinforcing the model's validity and the reliability of the constructs being measured. The goodness-of-fit indices for the CFA model, as shown in Table 5, provide a comprehensive assessment of the model's performance. The CFI stands out with a value of 0.9847, which indicates an excellent fit between the hypothesized model and the observed data. This high CFI value suggests that the model effectively captures the relationships among the variables under study. Furthermore, the RMSEA value of 0.0282 is another indicator of a strong model fit. Typically, RMSEA values below 0.05 are considered to indicate a close fit of the model

TABLE 4 Data validation and standardized CFA estimates.

Dimension	Correlation with total	Cronbach's α	CR	AVE	CFA standardized Parameter estimates	CFA path list P-value
Knowledge						
KNW1	0.57	0.84	0.84	0.52	0.71	<0.0001
KNW2	0.67				0.74	<0.0001
KNW3	0.61				0.68	<0.0001
KNW4	0.7				0.76	<0.0001
KNW5	0.69				0.71	<0.0001
Social						
SOC1	0.55	0.79	0.78	0.42	0.75	<0.0001
SOC2	0.62				0.75	<0.0001
SOC3	0.61				0.59	<0.0001
SOC4	0.50				0.52	<0.0001
SOC5	0.52				0.60	<0.0001
Environment						
ENV1	0.65	0.85	0.89	0.73	0.82	<0.0001
ENV2	0.82				0.81	<0.0001
ENV3	0.68				0.93	<0.0001
Resources						
RES1	0.36	0.74	0.71	0.40	0.45	<0.0001
RES2	0.56				0.62	<0.0001
RES3	0.59				0.64	<0.0001
RES4	0.64				0.73	<0.0001
Regulatory						
REG1	0.70	0.84	0.84	0.64	0.78	<0.0001
REG2	0.76				0.84	<0.0001
REG3	0.69				0.78	<0.0001
Risk						
RSK1	0.66	0.83	0.82	0.54	0.68	<0.0001
RSK2	0.66				0.80	<0.0001
RSK3	0.66				0.78	<0.0001
RSK4	0.70				0.68	<0.0001

TABLE 5 Goodness of fit indices.

Index	Fit summary	Value
Absolute Index	Chi-Square	240.9
	Pr > Chi-Square	0.22
	Standardized RMR (SRMR)	0.08
	Goodness of Fit Index (GFI)	0.84
Parsimony Index	Adjusted GFI (AGFI)	0.770
	RMSEA Estimate	0.028
Incremental Index	Bentler Comparative Fit Index	0.98

concerning the degrees of freedom. Additionally, the GFI value (0.8401), although slightly below the ideal threshold of 0.90, still reflects a good fit. These indices collectively suggest that the CFA model provides a valid framework for interpreting the measured constructs.

4.4 Structural Equation Modeling (SEM)

SEM was applied to the data using the PROC CALIS procedure in SAS, and the results obtained are illustrated in Table 6. The SEM model was evaluated for its goodness-of-fit through various indices, such as the RMSEA reported at 0.0750, indicating a good fit, and the CFI stood at 0.8716. Although the SRMR was 0.0997 and GFI was 0.7538, which are slightly below the optimal levels, they still underscore a moderate fit, considering the diversity and complexity of the constructs analyzed. In assessing the impact of the 6 dimensions on stakeholders' perceptions of biomimicry adoption in the UAE construction industry, the SEM results provided valuable insights. The analysis confirmed that the Knowledge dimension significantly influences perceptions, as evidenced by a path coefficient significance (p-value = 0.0031), supporting Hypothesis 1. Conversely, Hypotheses 2, 3, and 4 pertaining to the Social, Environment, and Resources dimensions respectively, did not show significant influences on perception, with p-values indicating non-significance (p-value = 0.8193, p-value = 0.7805, and p-value = 0.6304, respectively). The Regulatory dimension's significant influence suggests that regulatory factors play a crucial role in shaping perceptions, supporting Hypothesis 5 (p-value = 0.0082). Additionally, the Risk dimension demonstrated a significant negative impact on perceptions ($p = 0.0070$), aligning with Hypothesis 6. This suggests that higher perceived risks may deter stakeholders' positive perceptions of biomimicry. Moreover, the pathway from Perception to Intention was notably significant ($p < 0.0001$), indicating that perceptions strongly influence the intention to adopt biomimicry practices. These findings highlight the pivotal role of knowledge, regulatory, and risk considerations in shaping stakeholders' attitudes and intentions toward biomimicry in construction.

The SEM analysis offers insightful revelations into how various dimensions influence stakeholders' perceptions toward biomimicry adoption in the UAE construction industry, emphasizing the roles of knowledge, regulatory frameworks, and perceived risks. The significant impact of the Knowledge dimension on perceptions highlights its crucial role in fostering a favorable environment for biomimicry adoption within the UAE construction industry. This dimension, encapsulating awareness, professional knowledge, educational integration, and the presence of practical examples, is crucial in fostering a supportive environment for biomimicry adoption as discussed in various studies (Aanuoluwapo and Aigbavboa, 2019b; Aanuoluwapo Oguntona and Aigbavboa, 2019; Adekunye and Oke, 2024; Gamage and Hyde, 2012; Jones et al., 2024; Oguntona and Aigbavboa, 2019; Silva et al., 2024). Stakeholders who are well-informed about biomimicry's benefits and applications are more likely to appreciate its value and advocate for its integration into construction projects. The strong association between knowledge and stakeholder perceptions indicates that understanding biomimicry's principles, applications, and benefits is fundamental to its acceptance and integration into construction practices. This finding suggests an imperative to reinforce efforts in enhancing educational curricula and continuous professional development in biomimicry. Through the integration of biomimicry into academic curricula and professional development programs, the construction industry can equip its workforce with the necessary skills and insights to implement these practices effectively. This educational push needs to highlight not only the theoretical aspects but also practical implementations and success stories. Showcasing real-world examples where biomimicry has led to tangible benefits can help stakeholders visualize its potential and foster a deeper appreciation for innovative, sustainable practices. Moreover, such initiatives could spur intellectual curiosity and drive research and development efforts, further embedding biomimicry within the sector's innovation landscape.

Additionally, regulations can serve as both catalysts and barriers; hence, understanding their role is pivotal in the context of new technological adoptions like biomimicry. The Regulatory dimension's significant impact underscores the importance of a supportive legislative and policy framework in advancing biomimicry adoption, which was anticipated by the existing body of knowledge (Aanuoluwapo and Aigbavboa, 2019b; Aanuoluwapo Oguntona and Aigbavboa, 2019; Adekunye and Oke, 2024; Gamage and Hyde, 2012; Jones et al., 2024; Oguntona and Aigbavboa, 2017; Silva et al., 2024). Effective policy frameworks can accelerate the adoption of innovative practices by providing clarity, removing uncertainties, and offering incentives, which align biomimicry with national sustainability goals. This suggests that policymakers should consider revising construction codes to incorporate biomimicry principles, develop incentives that encourage its use, and possibly mandate its application in certain types of projects to push broader adoption. Additionally, the integration of biomimicry into regulatory standards can ensure that these innovative practices are not just optional enhancements but fundamental aspects of construction projects. Policymakers and regulatory bodies should collaborate with academic institutions and industry leaders to ensure that regulations are both practical and conducive to fostering innovation.

Conversely, the Risk dimension's negative influence on perception highlights the barriers imposed by perceived risks associated with biomimicry. Concerns about costs,

TABLE 6 SEM path list.

Path	Parameter	Estimate	Standard error	p-value
Knowledge→KNW1	1	0.65	0.11	<0.0001
Knowledge→KNW2	2	0.73	0.10	<0.0001
Knowledge→KNW3	3	0.68	0.10	<0.0001
Knowledge→KNW4	4	0.79	0.09	<0.0001
Knowledge→KNW5	5	0.77	0.10	<0.0001
Social→SOC1	6	0.76	0.07	<0.0001
Social→SOC2	7	0.75	0.06	<0.0001
Social→SOC3	8	0.64	0.08	<0.0001
Social→SOC4	9	0.59	0.10	<0.0001
Social→SOC5	10	0.59	0.06	<0.0001
Environment→ENV1	11	0.85	0.06	<0.0001
Environment→ENV2	12	0.81	0.05	<0.0001
Environment→ENV3	13	0.92	0.06	<0.0001
Resources→RES1	14	0.41	0.07	0.0002
Resources→RES2	15	0.62	0.07	<0.0001
Resources→RES3	16	0.76	0.07	0.0269
Resources→RES4	17	0.82	0.07	<0.0001
Regulatory→REG1	18	0.76	0.07	<0.0001
Regulatory→REG2	19	0.85	0.07	<0.0001
Regulatory→REG3	20	0.79	0.06	<0.0001
Risk→RSK1	21	0.66	0.08	<0.0001
Risk→RSK2	22	0.78	0.08	<0.0001
Risk→RSK3	23	0.79	0.08	<0.0001
Risk→RSK4	24	0.68	0.07	<0.0001
Knowledge→Perception	25	0.38	0.13	0.0031
Social→Perception	26	0.04	0.17	0.8193
Environment→Perception	27	0.05	0.18	0.7805
Resources→Perception	28	0.11	0.24	0.6304
Regulatory→Perception	29	0.36	0.14	0.0082
Risk→Perception	30	−0.35	0.13	0.0070
Perception→Intention	31	0.42	0.07	<0.0001

performance uncertainties, and the time needed for effective implementation represent substantial barriers, as deduced in multiple studies (Aanuoluwapo and Aigbavboa, 2019b; Aanuoluwapo Oguntona and Aigbavboa, 2019; Adekunye and Oke, 2024; Jones et al., 2024; Silva et al., 2024). These findings indicate a need for comprehensive risk assessment frameworks that can quantify and mitigate these perceived risks. Pilot projects and case studies that demonstrate the successful implementation and benefits of biomimicry can serve as powerful tools to mitigate perceived risks. These projects can provide empirical evidence of efficiency gains, cost savings, and other benefits, thereby persuading stakeholders of biomimicry's efficacy and value. Additionally, developing and disseminating guidelines on the implementation process can help standardize practices and reduce uncertainties, further fostering confidence among industry stakeholders. Finally, the pathway from perception to intention is critical, reinforcing the notion that how stakeholders perceive biomimicry significantly influences their willingness to adopt such practices. This path suggests that by positively influencing perceptions through targeted education, supportive regulations, and effective risk management, the construction industry can significantly enhance the adoption rates of biomimicry. Collaborative efforts between industry leaders, educators, and policymakers are essential to cultivate a more informed and receptive environment. This collective approach can help translate positive perceptions into concrete actions and widespread adoption of biomimicry, ultimately contributing to sustainability and innovation in construction practices.

In the context of the SEM analysis investigating the impact of various dimensions on stakeholder perceptions towards biomimicry in the UAE construction industry, several paths were found to be non-significant, which include the Social, Environment, and Resources dimensions. It is crucial to explore the potential reasons behind these findings, which could offer insights into areas that may require further investigation. The Social dimension's non-significance in influencing perceptions towards biomimicry adoption is an intriguing outcome. This dimension, which reflects the impact of biomimicry on occupant health, productivity, aesthetic values, and collaborative practices in construction projects, might be expected to resonate strongly with stakeholders as anticipated by (Aanuoluwapo and Aigbavboa, 2019a; Silva et al., 2024). However, the lack of significant influence suggests that while stakeholders may acknowledge the social benefits of biomimicry, these factors alone are insufficient to alter their overall perceptions significantly due to a predominant focus on economic and practical aspects over social benefits.

Similarly, the non-significant influence of the Environment dimension is noteworthy, especially given the current global emphasis on sustainable practices. This dimension covers energy management, resource and waste reduction, and water management innovations, all crucial for sustainable construction (Jones et al., 2024; Oguntona and Aigbavboa, 2017; Pugalenthi et al., 2024). This nonsignificant pathway indicates that stakeholders may not perceive immediate or direct environmental benefits from biomimicry in construction. This could be due to viewing such benefits as long-term outcomes, or it may highlight a disconnect between the theoretical advantages of biomimicry and its practical, observable implementations in current projects. The Resources dimension also did not have a significant impact on perceptions. This dimension relates to the availability of materials, technological innovation, and structural efficiency facilitated by biomimicry, as explained by several studies (Aanuoluwapo and Aigbavboa, 2019b; 2019a; Aanuoluwapo Oguntona and Aigbavboa, 2019; Oguntona and Aigbavboa, 2017; Pugalenthi et al., 2024; Silva et al., 2024). The non-significant result could be attributed to the lack of understanding about how these resources can be effectively utilized in construction. These non-significant findings suggest several implications for research and practice. They underscore the need for targeted educational efforts to enhance stakeholder understanding of how social and environmental benefits can be tangibly realized through biomimicry. They point to possible underdevelopment in market readiness and resource availability, which could be inhibiting the broader acceptance of biomimicry. Future research might focus on qualitative studies to explore these dimensions more deeply, uncovering underlying perceptions and barriers that quantitative methods might not fully reveal. Additionally, industry-wide initiatives could be designed to communicate the practical benefits of biomimicry in these dimensions, increasing their perceived influence on stakeholders.

Therefore, it is evident that the adoption of biomimicry in the UAE construction industry is significantly influenced by the interplay of knowledge, regulatory support, and risk perceptions. The findings highlight the critical role of enhancing stakeholder knowledge and understanding of biomimicry to foster positive perceptions and intentions. Regulatory frameworks also emerge as pivotal in facilitating the adoption process, indicating the need for policies that are both supportive and strategically aligned with national sustainability goals. Additionally, addressing the perceived risks associated with biomimicry is crucial for mitigating concerns and enhancing its attractiveness as a viable sustainable practice. Hence, industry stakeholders must collaborate to promote an integrative approach that combines education, policy innovation, and risk management to optimize the adoption of biomimicry. These initiatives are expected to accelerate sustainable transformation in construction while advancing broader environmental and economic objectives, ultimately positioning the UAE as a leader in sustainable practices.

Lastly, to enhance robustness and interpretability, the analytical results were further evaluated in light of relative importance as discussed in the following section. Whereas the SEM path coefficients identified which dimensions exerted a statistically significant influence on perception and intention, the RII analysis ranks specific indicators within each dimension. This dual-layered approach allows for both model-level and indicator-level triangulated insights into the drivers and barriers shaping biomimicry adoption in the UAE construction sector.

4.5 Relative Importance Index (RII)

Upon thoroughly examining the SEM results, the study now shifts focus to a more granular analysis using the RII, which will enable the individual ranking of the indicators within each of the six dimensions. The RII is a widely used statistical tool in academic research for prioritizing variables and assessing their significance. It is effective in fields such as construction management, project assessment, and the social sciences, where it converts qualitative survey data into quantitative measures reflecting the relative importance of factors. Known for its simplicity, adaptability, and precision, the RII provides a standardized framework for ranking variables, enabling data-driven decision-making, prioritization, and comparative analysis. Its utility is evident in contexts requiring stakeholder input, such as identifying sustainability drivers in construction or evaluating perceptions in organizational studies. The RII is calculated using the following formula (Aravindh et al., 2022):

$$\text{RII} = \frac{\sum w}{A * N} = \frac{5 * n5 + 4 * n4 + 3 * n3 + 2 * n2 + 1 * n1}{5 * (n1 + n2 + n3 + n4 + n5)}, (0 < \text{RII} \leq 1)$$

Where: w: Weight assigned to each factor by respondents (derived from a Likert scale), *A*: Maximum possible weight on the scale (5 for a 5-point scale), *N*: Total number of respondents, n1 – number of respondents who selected “Strongly Disagree”, n2 - number of respondents who selected “Disagree”, n3 - number of respondents who selected “Neutral”, n4 - number of respondents who selected “Agree”, and n5 - number of respondents who selected “Strongly Agree”. The index, ranging from 0 to 1, reflects the importance of factors—values closer to 1 indicate high significance and strong consensus among respondents, while lower values closer to 0 suggest lesser criticality. Table 7 organizes the findings under the six literature-based dimensions, each elucidating key indicators that influence biomimicry adoption.

The SEM analysis identified the Knowledge, Regulatory, and Risk dimensions as statistically significant in shaping stakeholders’ perceptions. The Knowledge dimension, in particular, emerged as a critical driver, with a significant path coefficient ($p = 0.0031$). This was corroborated by the RII results, where the indicator “Awareness of Biomimicry” (KNW1) ranked highest within its category, necessitating enhanced stakeholder understanding through targeted campaigns and engagement. Additionally, a robust grasp of ecosystem complexities (KNW5) and the availability of practical examples (KNW4) underscore the value of integrating ecological principles and showcasing successful biomimetic applications, as they ranked second and third.

Similarly, the Regulatory dimension was validated as a significant determinant in the SEM model ($p = 0.0082$), reflecting the influence of legislative and policy frameworks on stakeholder perceptions. The RII findings further support this, as “Governmental Support” (REG3) was identified as the most critical regulatory indicator, highlighting the critical role of proactive regulatory frameworks and incentives in fostering biomimicry adoption. This convergence emphasizes the importance of policy instruments and institutional backing in driving sustainability-oriented innovation. Policy and Educational Support (REG1) and Construction Codes Involving Biomimicry (REG2) ranked second and third, respectively. While these aspects are significant, the findings suggest that stakeholders prioritize tangible governmental actions over broader policy frameworks or amendments to construction codes.

Furthermore, the Risk dimension demonstrated a significant negative influence in the SEM model ($p = 0.0070$), indicating that heightened risk perceptions can act as deterrents to biomimicry adoption. Consistently, the RII analysis ranked

TABLE 7 RII rankings of the indicators.

Dimensions	Code	Indicators	Individual ranking
Knowledge factor (KNW)	KNW1	Awareness of biomimicry	1
	KNW5	Understanding of nature’s complexities	2
	KNW4	Presence of practical examples	3
	KNW3	Education	4
	KNW2	Professional knowledge	5
Social factor (SOC)	SOC5	Collaboration in biomimicry projects	1
	SOC1	Impact on occupant health and productivity	2
	SOC2	Aesthetic impact	3
	SOC3	Employment opportunities	4
	SOC4	Market condition	5
Environmental factor (ENV)	ENV1	Energy management	1
	ENV2	Resource management and waste reduction	2
	ENV3	Water management	3
Resources factor (RES)	RES1	Resource and material availability	1
	RES2	Technology innovation	2
	RES4	Resilience & adaptability	3
	RES3	Structural efficiency	4
Regulatory factor (REG)	REG3	Governmental support	1
	REG1	Policies	2
	REG2	Construction codes	3
Risk factor (RSK)	RSK1	Cost implications	1
	RSK2	Uncertainty	2
	RSK4	Industry structure	3
	RSK3	Time	4

"Cost Implications of Biomimicry Adoption" (RSK1) as the top concern, emphasizing financial uncertainty as a dominant barrier. Performance Efficiency and Effectiveness Uncertainty (RSK2) ranked second, reflecting apprehensions regarding the reliability of biomimetic solutions. Industry Structure (RSK4) and Time Allocation (RSK3) ranked third and fourth, respectively, indicating that while structural and temporal challenges are relevant, they are perceived as less critical. The consistency across both methods confirms that risk perceptions, particularly those related to cost, performance, and implementation complexity, must be effectively managed to facilitate broader adoption.

In contrast, the Social, Environment, and Resources dimensions did not exhibit statistically significant effects in the SEM model. However, RII results suggest that indicators within these dimensions are still perceived as important by stakeholders. Within the Social dimension, Collaboration in Biomimicry Projects (SOC5) emerged as the most important aspect, underscoring the necessity of interdisciplinary teamwork to achieve effective biomimetic solutions. This aligns with the inherently collaborative nature of biomimicry, which requires synergies between architects, engineers, ecologists, and other stakeholders. Impact on Occupant Health and Productivity (SOC1) and Aesthetic Impact of Biomimicry (SOC2) ranked second and third, reflecting the perceived social advantages of biomimetic designs in enhancing occupant wellbeing and aesthetic appeal. However, Employment Opportunities from Biomimicry (SOC3) and Market Condition (SOC4) ranked lower, indicating that the economic and market-driven benefits of biomimicry remain underdeveloped. Furthermore, the Environmental dimension reveals a strong emphasis on Energy Management through Biomimicry (ENV1), which was the highest-ranked indicator. This underscores the recognition of biomimicry's potential to enhance energy efficiency through nature-inspired innovations such as natural cooling and insulation strategies. Resource Management and Waste Reduction (ENV2) ranked second, highlighting the importance of emulating natural recycling processes to achieve sustainable resource utilization. Water Management Innovations (ENV3) ranked third, suggesting that while water conservation is valued, it is perceived as secondary to energy and resource management in the UAE. Moreover, the Resources dimension identifies Biomimicry Resource and Material Availability (RES1) as the most critical indicator, underscoring the necessity for accessible biomimetic materials and resource databases to facilitate adoption. Technology Innovation (RES2) and Resilience & Adaptability (RES4) were ranked second and third, reflecting the importance of technological advancements and adaptability to environmental challenges inspired by biomimicry. Structural Efficiency (RES3) ranked lowest, suggesting that the structural benefits are perceived as less impactful compared to other resource-related considerations. These findings suggest a perceptual dissonance: while stakeholders acknowledge the relevance of social, environmental, and resource-related indicators, such factors may not directly influence their overall perceptions or intentions, possibly due to their perceived abstractness, delayed impact, or implementation complexity.

This comparative analysis reveals that while the RII highlights the perceived significance of individual indicators, SEM offers empirical validation of the latent dimensions that statistically influence stakeholder perceptions. The triangulation of these methods not only strengthens the overall credibility of the findings but also contributes to a more refined theoretical understanding of adoption dynamics within emerging sustainability paradigms such as biomimicry. These insights highlight the necessity of a multifaceted strategy for fostering biomimicry adoption in the UAE construction sector, one that simultaneously amplifies enabling factors and mitigates prevailing barriers. Enhancing stakeholder awareness, promoting interdisciplinary collaboration, and embedding biomimicry into educational and vocational training programs are foundational steps. Equally important is the establishment of robust governmental support through well-aligned policies, regulatory frameworks, and financial incentives. Addressing challenges related to material availability, technological readiness, and cost implications through targeted interventions and cost-benefit analyses can further alleviate resistance to adoption. Moreover, the dissemination of practical case studies showcasing successful biomimicry applications can serve to validate its benefits and inspire broader stakeholder engagement. Collectively, these measures can support the integration of biomimicry as a transformative approach to sustainable construction in the UAE.

5 Conclusion

5.1 Summary of the findings

This study has elucidated the multifaceted perceptions governing the adoption of biomimicry within the UAE's construction industry, a sector pivotal for its socio-economic development yet significantly impactful on the environment due to its resource-intensive nature. Through a comprehensive investigation employing SEM and RII, this research has identified key factors that influence stakeholders' willingness to integrate biomimicry into construction practices. The SEM analysis confirmed that knowledge, regulatory frameworks, and perceived risks are critical determinants shaping stakeholders' perceptions and intentions toward adopting biomimicry. The knowledge dimension emerged as a significant influence, underscoring the necessity for enhanced educational initiatives and professional development to foster a comprehensive understanding of biomimicry's benefits and applications. The findings suggest prioritizing the integration of biomimicry into academic curricula and continuous professional development through awareness campaigns, workshops, and certification programs to enhance its adoption and acceptance in construction.

Moreover, the regulatory dimension's notable impact suggests that a conducive regulatory environment is indispensable for facilitating the adoption of biomimicry. This dimension's significance highlights the potential of governmental interventions, such as incentives and revised construction codes, to foster a widespread integration of biomimicry in construction. Moreover, addressing the identified risks associated with biomimicry adoption, particularly the financial and performance-related uncertainties, is essential for mitigating stakeholders' concerns and enhancing the perceived feasibility and effectiveness of biomimetic solutions. The

RII analysis refined these insights by ranking the importance of specific indicators within each dimension, thereby pinpointing the most influential factors as perceived by stakeholders. This granular understanding enables targeted interventions to address the most pressing barriers and leverage the strongest enablers to biomimicry adoption. For instance, enhancing the availability of biomimicry resources and demonstrating successful practical applications could significantly reduce apprehensions regarding the practicality and effectiveness of biomimetic strategies. Conclusively, this study not only contributes to the theoretical discourse on sustainable construction practices but also offers pragmatic insights for practitioners and policymakers aiming to advance the adoption of biomimicry in the UAE as discussed in the next subsection.

5.2 Implications

The findings of this research offer significant theoretical contributions and practical implications for key stakeholders, moving beyond summary to provide actionable insights. To begin with, for the scientific community, this study contributes a validated empirical framework for analyzing the adoption of emerging sustainable technologies in construction. By applying SEM to stakeholder perceptions of biomimicry in a non-Western context, it shifts the academic discourse from primarily conceptual or technical reviews toward an empirical, socio-technical understanding of implementation. The model serves as a robust baseline for future comparative studies and provides a theoretical foundation for investigating technology adoption in other emerging economies facing similar sustainability pressures. Furthermore, for policymakers and regulatory bodies, the findings provide evidence-based support for targeted policy interventions. The strong influence of the regulatory dimension implies that passive support is insufficient and that proactive governance is required. The implication is that government bodies in the UAE can directly accelerate adoption by developing clear construction codes that incorporate biomimetic standards, offering financial incentives for pilot projects, and streamlining approval processes for innovative, bio-inspired materials and designs. Additionally, for industry professionals such as architects, engineers, and developers, this research highlights that the primary barriers to adoption are not insurmountable technical challenges but manageable factors related to knowledge, risk perception, and regulation. The implication is that firms can gain a competitive advantage by investing strategically in professional development, fostering interdisciplinary collaboration between designers and biologists, and championing pilot projects to build a portfolio of local, successful case studies. Notably, the RII analysis acts as a guide, allowing industry leaders to prioritize resources to tackle the most significant barriers first. Lastly, the prominence of the knowledge dimension sends a clear signal to educators. The implication is that existing architectural and engineering curricula in the region must evolve to integrate biomimicry as a core competency, not just a niche specialization. This study justifies the development of dedicated courses, workshops, and certification programs to equip the next-generation of professionals with the skills and understanding necessary to implement these advanced sustainable solutions effectively.

5.3 Future directions

While this study provides valuable insights, its findings should be considered in light of its geographical focus on the UAE. Building on the implications outlined above, several avenues for future research emerge. For instance, future research could involve cross-regional comparative analyses between the UAE and other regions with distinct climatic, economic, and cultural contexts to identify universal drivers and barriers to biomimicry adoption. Additionally, conducting longitudinal studies to track the long-term effects of biomimicry implementations in construction could provide deeper insights into their sustainability impacts, cost-effectiveness, and operational efficiencies. Furthermore, developing new technologies that enhance the application of biomimicry in construction could also be a useful area of research. This might include advancements in materials science to develop new biomimetic materials with enhanced properties, or innovations in digital modeling that allow for more precise emulation of natural systems. Further, it is integral to create sustainability metrics and benchmarking tools that can more accurately measure the environmental, social, and economic impacts of biomimicry in construction. These tools would help practitioners objectively assess the effectiveness of biomimetic strategies and facilitate their broader acceptance and implementation. By pursuing these directions, researchers and practitioners can advance the implementation of biomimicry in construction, leading to more sustainable building practices worldwide.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

SaA: Investigation, Validation, Conceptualization, Software, Formal Analysis, Methodology, Data curation, Writing – review and editing, Writing – original draft. TJ: Formal Analysis, Validation, Software, Methodology, Investigation, Conceptualization, Writing – original draft, Writing – review and editing. KA: Writing – original draft, Data curation, Investigation, MA: Investigation, Data curation, Writing – original draft. SeA: Methodology, Conceptualization, Resources, Visualization, Writing – review and editing. SB: Investigation, Visualization, Writing – review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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