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Artificial Intelligence for Disaster Risk Management in the Beauty Industry

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Abstract

The increasing reliance on AI in the beauty industry has significantly enhanced various business operations, including customer experience personalization, supply chain management, and product innovation. However, this integration also introduces vulnerabilities, particularly in the realm of Disaster Risk Management (DRM). This study explores the role of AI in mitigating disaster-related risks within the beauty industry, focusing on predictive analytics, supply chain resilience, cybersecurity, and crisis response. A qualitative research approach was adopted, drawing on an extensive review of secondary data sources, including industry reports, case studies, and peer-reviewed literature. Findings indicate that AI-driven predictive models can enhance disaster preparedness by forecasting potential risks, enabling proactive decision-making, and improving operational continuity. Additionally, AI facilitates real-time monitoring of supply chains, allowing for swift identification and resolution of disruptions. Despite these advantages, challenges such as data privacy concerns, algorithmic biases, and regulatory compliance remain critical considerations. Ethical implementation and robust security measures are essential to maximizing AI's benefits in DRM. Future research should focus on developing standardized risk assessment frameworks and fostering industry-wide collaboration to refine AI-driven DRM strategies.

Keywords: Artificial Intelligence, Disaster Risk Management, Beauty Industry, Supply Chain Resilience, Predictive Analytics, Cybersecurity

Introduction

The omnipresence of social media platforms has amplified societal expectations surrounding beauty, self-expression, and personal branding, making physical appearance a central component of identity construction. Every post, selfie, and video serves as a performative act, reinforcing the notion that one's outward image is not only a reflection of self-worth but also a key determinant of social validation and digital influence. This pervasive culture of spectacle fosters an environment where beauty is not merely a personal attribute but a social currency, shaping how individuals perceive themselves and others (Shahghasemi, 2021) [35]. Building on this, the influence of global narratives on self-identity cannot be overlooked. As Sabbar *et al*. (2023) [33] highlight, sustained exposure to global narratives on social media can shape how individuals perceive their own societies, influencing self-identity and cultural perspectives. This has created an increasing demand for beauty products and services. The beauty industry, encompassing sectors such as cosmetics, skincare, salons, spas, and beauty retail, is increasingly integrating AI to enhance personalized customer experiences, optimize supply chains, and drive product innovation. However, this growing reliance on AI also introduces new vulnerabilities, particularly in the context of DRM (Kim, *et al*., 2021) [21]. Disasters—ranging from health crises such as pandemics to scandals and social media mass protests, to legal and policy-related issues—can disrupt operations, supply chains, and customer interactions. The integration of AI into these processes necessitates a comprehensive examination of how AI can be leveraged to predict, mitigate, and manage disaster-related risks within the beauty industry (Duane, 2024) [9].

AI's role in DRM is multifaceted. Predictive analytics, powered by machine learning algorithms, can forecast natural disasters

and supply chain disruptions, enabling businesses to proactively manage inventory and distribution channels (Georgievskaya, 2024) [11]. For instance, AI models can analyze weather patterns to anticipate logistical challenges, allowing companies to adjust their operations accordingly (Shahghasemi, 2025) [36]. In the beauty industry, where product availability and timely delivery are crucial, such predictive capabilities can be invaluable.

Moreover, AI enhances supply chain resilience by optimizing logistics and providing real-time monitoring. By analyzing data from various sources, AI systems can identify potential bottlenecks or vulnerabilities in the supply chain, facilitating timely interventions. This is particularly pertinent for beauty businesses that rely on a global network of suppliers and distributors. For example, during the COVID-19 pandemic, companies with AI-enabled supply chain management systems were better equipped to navigate disruptions and maintain product availability (Zheng, 2022) [46].

However, the deployment of AI in DRM also presents challenges. Data privacy concerns arise as AI systems often require access to sensitive information to function effectively. Ensuring compliance with data protection regulations, such as the General Data Protection Regulation (GDPR) in Europe, is essential to maintain customer trust and avoid legal repercussions. Aghigh *et al*. (2022) [1] highlight that the effectiveness of laws depends on their alignment with formal and substantive principles, as inefficient regulations often fail to ensure compliance and can exacerbate societal challenges. Additionally, the reliance on AI systems necessitates robust cybersecurity measures to protect against potential cyber threats, which could compromise both operational integrity and customer data. Recent research emphasizes the critical need for AI literacy frameworks that address algorithmic bias, data privacy concerns, and ethical engagement to ensure responsible navigation of AI-mediated digital societies (Khodabin *et al*., 2024) [18].

While AI offers significant potential to enhance disaster risk management in the beauty industry through predictive analytics and supply chain optimization, it is imperative to address the associated challenges. The influence of tech giants like Google on academic research raises concerns about the objectivity of knowledge production in AI. As Sarfi *et al*. (2021) [34] argue, corporate funding can shape research priorities, potentially introducing biases. In the beauty industry, where AI is increasingly used for disaster risk management, ensuring ethical development and deployment of AI is critical. By fostering independent research and promoting transparency, beauty companies can build consumer trust and avoid corporate-driven biases in AI applications. Implementing robust data privacy policies and cybersecurity measures will be crucial in leveraging AI effectively and responsibly. As the beauty industry continues to evolve, integrating AI into DRM strategies will be key to building resilience against future disruptions.

Disaster Risk Management

DRM is a systematic approach to identifying, assessing, and reducing risks associated with natural and human-induced hazards. It encompasses a broad range of activities aimed at minimizing vulnerabilities, enhancing resilience, and ensuring effective response and recovery in the event of a disaster. The concept of DRM has gained significant traction in recent decades, particularly as the frequency and intensity of disasters have increased due to factors such as climate change, urbanization, and environmental degradation. At its core, DRM seeks to protect lives, livelihoods, and assets while promoting sustainable development. This essay explores the key components of DRM, its importance, and the challenges associated with its implementation.

Disaster risk is a function of three interrelated factors: Hazards, vulnerability, and exposure. Hazards are natural or human-induced events that have the potential to cause harm, such as earthquakes, floods, hurricanes, or industrial accidents. Vulnerability refers to the susceptibility of individuals, communities, or systems to the adverse impacts of these hazards. It is influenced by factors such as poverty, inadequate infrastructure, and lack of access to resources. Exposure, on the other hand, refers to the presence of people, assets, or ecosystems in areas that are prone to hazards. Disaster risk arises when these three elements converge, creating the potential for significant harm (Asih, Pandin, Yusuf, & Supriyadi, 2023; Cardona, Ordaz, Mora, Salgado-Gálvez, & Bernal, 2014) [2, 7].

The goal of DRM is to break this nexus by addressing each component. This involves reducing the likelihood and severity of hazards, minimizing vulnerability, and managing exposure. For example, constructing earthquake-resistant buildings reduces vulnerability, while land-use planning can limit exposure by preventing development in high-risk areas.

DRM is typically organized around four key pillars: Prevention, preparedness, response, and recovery. Each pillar plays a critical role in minimizing risks and ensuring effective outcomes, and the integration of AI can significantly enhance the effectiveness of these efforts. AI's ability to process vast amounts of data, identify patterns, and make predictions makes it a powerful tool for addressing the complexities of disaster risk.

In the prevention phase, AI can help identify and mitigate risks before disasters occur. By analyzing historical data, environmental factors, and climate patterns, AI algorithms can predict the likelihood of events such as floods, earthquakes, or wildfires. For example, machine learning models can process satellite imagery and weather data to identify areas at high risk of landslides or flooding, enabling authorities to implement preventive measures like reinforcing infrastructure or relocating vulnerable communities. AI can also monitor critical infrastructure, such as bridges and dams, in real time using sensors that detect structural weaknesses or anomalies. This allows for timely maintenance and reduces the risk of failure during disasters. Additionally, AI supports environmental conservation efforts by analyzing deforestation, soil erosion, and urban sprawl, helping to mitigate risks like flooding or landslides.

The preparedness phase focuses on planning and capacity-building to ensure an effective response when a disaster strikes. AI enhances preparedness by improving early warning systems, optimizing resource allocation, and facilitating training. Early warning systems powered by AI can analyze real-time data from sensors, satellites, and social media to detect early signs of disasters, such as rising water levels or seismic activity, and issue timely alerts to at-risk populations. AI also optimizes the allocation of resources, such as emergency supplies and personnel, by analyzing historical disaster data, population density, and

infrastructure maps. This ensures that critical resources are prepositioned in areas most likely to be affected. Furthermore, AI-driven simulations and virtual reality tools can enhance training for emergency responders, providing realistic scenarios to improve their readiness and decision-making skills.

During the response phase, AI plays a crucial role in coordinating efforts and saving lives. AI-powered systems can analyze real-time data from drones, satellites, and social media to provide situational awareness, helping emergency responders identify the most affected areas and allocate resources efficiently. For example, AI can process social media posts to locate individuals in need of rescue or track the movement of displaced populations. Natural language processing (NLP) tools can also analyze emergency calls and messages to prioritize responses based on urgency. Additionally, AI can optimize logistics by predicting the fastest routes for delivering aid, even in disrupted environments, ensuring that help reaches those in need as quickly as possible.

In the recovery phase, AI assists in rebuilding and restoring communities after a disaster. AI-powered damage assessment tools can analyze satellite imagery and drone footage to evaluate the extent of destruction, enabling authorities to prioritize reconstruction efforts. Machine learning algorithms can also predict the long-term impacts of disasters, such as economic losses or health crises, helping governments and organizations plan recovery programs effectively. AI can streamline resource allocation during recovery by identifying the most critical needs, such as housing, healthcare, or infrastructure repair. Furthermore, AI supports psychological recovery by analyzing data from social media or surveys to identify communities in need of mental health support, ensuring a holistic approach to rebuilding.DRM is essential for safeguarding human lives, protecting economic assets, and promoting sustainable development. Disasters can have devastating consequences, including loss of life, displacement, and economic disruption (Haque & Etkin, 2007; Perazzini, 2020) [12, 31]. For example, the 2011 Tohoku earthquake and tsunami in Japan resulted in nearly 16,000 deaths and caused an estimated $360 billion in damages. By reducing disaster risk, DRM helps prevent such catastrophic outcomes.

Moreover, DRM contributes to sustainable development by addressing the root causes of vulnerability. Poverty, inequality, and environmental degradation are key drivers of disaster risk. By tackling these issues, DRM aligns with the United Nations Sustainable Development Goals (SDGs), particularly Goal 11, which aims to make cities and human settlements inclusive, safe, resilient, and sustainable. For instance, improving access to education and healthcare can reduce vulnerability by empowering individuals and communities to better cope with disasters.

DRM also has economic benefits. Investing in risk reduction measures can yield significant returns by preventing losses and reducing the need for costly post-disaster recovery. According to the World Bank, every dollar spent on disaster risk reduction can save up to seven dollars in recovery costs. This makes DRM a cost-effective strategy for governments and organizations.

Despite its importance, implementing DRM is fraught with challenges. One major obstacle is the lack of political will and financial resources. DRM often competes with other priorities for funding, and its long-term benefits may not be immediately apparent to policymakers. This can result in underinvestment in risk reduction measures, leaving communities vulnerable to disasters (Ling, Li, Liu, & Cai, 2021; Pais, Kim, Radke, & González, 2024; Soden, Wagenaar, Luo, & Tijssen, 2019) [22, 29, 37].

Another challenge is the complexity of disaster risk. Hazards are often interconnected, and their impacts can cascade across sectors and regions. For example, a hurricane can cause flooding, disrupt supply chains, and lead to economic losses. Addressing such complex risks requires integrated approaches that involve multiple stakeholders and sectors. However, coordination among these actors can be difficult, particularly in fragmented governance systems.

Climate change further complicates DRM by increasing the frequency and intensity of certain hazards, such as hurricanes, floods, and wildfires. This requires DRM strategies to be adaptive and forward-looking, anticipating future risks rather than simply addressing current ones. However, predicting the impacts of climate change is inherently uncertain, making it challenging to develop effective risk reduction measures.

Community engagement is another critical but often overlooked aspect of DRM. Local communities are the first responders in a disaster and possess valuable knowledge about their vulnerabilities and capacities. However, they are frequently excluded from decision-making processes, leading to solutions that may not be contextually appropriate. Ensuring meaningful participation of communities in DRM is essential for its success. However, the challenges of communication and engagement should not be ignored. As Mohammadi and Kharazmi (2021) [25] highlight, reliance on online platforms during crises exposes significant barriers, particularly in developing countries where inadequate technological infrastructure limits access to essential tools. These disparities hinder effective communication and engagement, making it harder for communities to participate in DRM efforts. Addressing these infrastructural gaps is crucial for ensuring inclusive and effective disaster risk management, particularly in industries like beauty that rely on AI-driven solutions for resilience.

To overcome these challenges, a holistic and inclusive approach to DRM is needed. This includes strengthening governance frameworks, increasing investment in risk reduction, and fostering collaboration among stakeholders. Governments should prioritize DRM in their national development plans and allocate adequate resources to it. International cooperation is also crucial, as many disasters transcend national borders and require collective action.

Innovation and technology can play a key role in enhancing DRM. Advances in data analytics, remote sensing, and artificial intelligence can improve risk assessment and early warning systems. For example, satellite imagery can be used to monitor flood-prone areas and predict potential disasters. Similarly, social media platforms can facilitate real-time communication during emergencies, enabling faster and more effective response.

Education and awareness-raising are equally important. By promoting a culture of safety and resilience, individuals and communities can be empowered to take proactive measures to reduce their risk. Schools, media, and community organizations can play a vital role in disseminating information and building capacity. Research shows that investing in education is both a strategic advantage and an

ethical responsibility, particularly in industries like beauty that rely on AI for disaster risk management. Educated employees are better equipped to navigate complex challenges, such as supply chain disruptions and cybersecurity threats, ensuring businesses remain resilient and adaptive in the face of disasters (Zamani *et al*., 2024) [44].

Review of Literature

At the time of writing, there is no study that reviews the role AI can play in DRM for the beauty industry. But the issues of disaster outcomes for beauty industry, using AI for better managing industries, and the role AI can play in the betterment of industry perofamance in the marketplace have been well studies. Mangtani *et al*. (2020) [24] examined the role of AI and Augmented Reality (AR) in the cosmetic and beauty industry, particularly in response to the behavioral shifts brought by the COVID-19 pandemic. The authors highlight how digitalization has transformed the beauty industry, emphasizing the increasing reliance on AI-driven solutions for personalized skincare and virtual product testing. The pandemic has accelerated the adoption of AI and AR technologies due to concerns over hygiene and social distancing, reducing the need for physical interaction in product trials and consultations. The paper details various applications of AI and AR, including AI-assisted skincare diagnostics, AR-powered virtual makeup applications, and AI-driven personalization of beauty products. Companies have developed AR mirrors, virtual hair-color testing tools, and AI-powered beauty advisors that recommend products based on facial analysis. These technologies enhance user experience by enabling consumers to test products virtually before purchase, thus addressing safety concerns while improving customer satisfaction. The study further outlines key drivers and advantages of AI in cosmetics, such as data-driven customization, efficiency in product recommendations, and enhanced consumer engagement through virtual experiences. AI-powered tools also contribute to dermatological advancements by diagnosing skin conditions and tailoring treatments accordingly. The authors conclude that AI and AR will continue to shape the future of the beauty industry, ensuring greater convenience, safety, and personalization in post-pandemic consumer interactions.

Wang *et al*. (2020) [43] examined the integration of AI and virtual reality (VR) within e-commerce platforms to enhance the medical beauty industry, focusing on Penghu as a case study. The study aimed to explore the economic impact of AI-driven virtual experiences on global markets and assess how digital innovations contribute to business growth and competitiveness. By leveraging AI and VR, the research highlighted how improved user experience, enhanced product accessibility, and interactive customer guidance could boost sales and strengthen industry relationships. The study applied the Task-Technology Fit (TTF) Theory, Theory of Reasoned Action (TRA), and Transaction Cost Theory (TCT) to evaluate the effectiveness of AI-powered e-commerce platforms in the medical beauty sector. A questionnaire survey was conducted, and Structural Equation Modeling (SEM) was used for statistical analysis. The findings indicated that AI integration significantly improved customer engagement and purchasing decisions by reducing transaction costs, enhancing decision-making efficiency, and increasing consumer trust. Additionally, the incorporation of AI into e-commerce platforms facilitated new business models, promoting the global competitiveness of local medical beauty providers. The authors concluded that AI-driven e-commerce strategies offer substantial economic benefits to the medical beauty industry, particularly in Penghu, by modernizing sales channels and optimizing user experience. The study emphasized the importance of continuous innovation in AI and VR applications to sustain market growth and industry competitiveness.

George and Renjith (2021) [10] review the evolution of safety and security risk assessment methodologies in process industries, highlighting the increasing adoption of Bayesian Networks (BNs) as a dynamic and effective tool for risk evaluation. The study underscores the interconnected nature of safety and security in industries handling hazardous materials, emphasizing that traditional risk assessment approaches have primarily focused on accident prevention rather than security threats. The authors analyze international journal articles published between 2000 and 2019, categorizing various risk assessment methodologies. They discuss the limitations of conventional quantitative risk assessment techniques, which are largely static and fail to accommodate new information in real-time. The 9/11 terrorist attack significantly shifted the focus towards security risk assessment, necessitating more advanced methodologies to address evolving threats. Bayesian Networks have emerged as a preferred approach due to their ability to update failure probabilities dynamically, represent conditional dependencies, and handle multi-state variables. The paper outlines the advantages of Bayesian Networks over traditional methods, such as Fault Tree Analysis (FTA) and Event Tree Analysis (ETA), while also identifying challenges in their application. The authors conclude that Bayesian Networks offer significant potential for improving risk assessment in process industries but call for further research to refine their implementation and integration with existing safety frameworks.

Johny (2021) [17] reviews the existing literature on risk factors in supply chain management (SCM) within an uncertain and competitive business environment. The study highlights the growing discourse among academics and practitioners regarding the challenges posed by business uncertainties, economic policies, and globalization, which disrupt supply chain networks and impact financial performance. The paper systematically analyzes research that includes "risk" in its title, keywords, or abstract, offering a theoretical perspective on supply chain risk management (SCRM). The findings indicate that unpredictable disruptions, including natural disasters and human-made crises, threaten supply chain stability and national economies. The study underscores the importance of effective risk mitigation strategies, which can enhance business competitiveness and resilience. Additionally, the research emphasizes that SCRM is integral to maintaining the efficiency of supply networks. Addressing risk through proactive strategies can help organizations navigate disruptions, improve operational continuity, and minimize financial losses. The study calls for further exploration into evolving risk management approaches to strengthen supply chain resilience against emerging global uncertainties.

Munawar *et al*. (2022) [27] review the role of disruptive technologies in disaster risk management, focusing on their integration within smart cities to enhance disaster

prediction, response, and recovery. The study categorizes state-of-the-art technologies such as the Internet of Things (IoT), AI, big data analytics, image processing, and smartphone applications, assessing their current applications and identifying gaps that hinder their broader adoption in disaster management. The authors emphasize the need for improved automation in disaster forecasting and risk assessment, particularly in urban environments. They analyze the relevance of disruptive technologies in flood prediction, hazard analysis, and risk mitigation, arguing that a data-driven approach can significantly enhance disaster preparedness. A novel framework is proposed that integrates big data analytics and AI to improve real-time decision-making and response strategies. Key barriers to adoption include data privacy concerns, interoperability issues, and the need for standardized regulations. The study concludes that smart cities must leverage these technologies to establish more resilient disaster management systems. Future research should explore ways to overcome technological and infrastructural challenges to ensure efficient disaster mitigation and recovery.

Büyüközkan *et al*. (2022) [6] provide a comprehensive review of urban resilience (UR) literature, analyzing both academic and industrial publications to assess key themes, trends, and research gaps in the field. Urban resilience is critical for cities to prepare for and respond to disasters, particularly those induced by climate change and extreme weather conditions. The COVID-19 pandemic further highlighted vulnerabilities in urban infrastructure, emphasizing the need for resilient strategies. The study reviews 146 journal articles and nine industrial reports published up to 2020, classifying them into three main categories: Literature reviews, conceptual models, and analytical models. The authors examine different approaches and analytical techniques used in UR research, distinguishing between theoretical contributions and practical applications. Industrial reports offer insights into resilience strategies adopted by practitioners, bridging the gap between theory and real-world implementation. Findings indicate that climate change is the most frequently discussed issue in UR literature, underscoring the urgency of adaptive and mitigation strategies. The study also identifies gaps in existing research, particularly in integrating interdisciplinary approaches, leveraging emerging technologies, and improving resilience assessment frameworks. Future research should focus on developing comprehensive urban resilience models that incorporate socio-economic, technological, and environmental dimensions.

Sofyan *et al*. (2022) [38] present a systematic review of crisis and disaster management in the halal tourism industry, aiming to develop a management framework grounded in Islamic teachings. The study highlights the importance of integrating religious principles into disaster resilience strategies for Muslim-majority tourism destinations. The research follows a grounded theory approach, systematically reviewing literature from 2000 to 2020. The analytical process includes open coding, axial coding, and selective coding, leading to the identification of 55 open codes, eight axial codes, and three selective codes. The findings reveal that Islamic teachings provide guidance on behavioral and psychological responses to crises but lack organization within modern crisis management frameworks. The study argues that halal tourism benefits from the inherent social and community resilience derived from Islamic values. The authors emphasize the practical implications of their findings for tourism planners and policymakers. By aligning crisis management strategies with religious principles, destinations catering to Muslim travelers can enhance their preparedness and response mechanisms. The study contributes to the broader discourse on sustainable and resilient tourism management by incorporating faith-based perspectives.

Bahaji (2022) [5] examines the intersection of smart beta investing and the environmental, social, and governance (ESG) transition, arguing that smart beta strategies—once seen as disruptive financial innovations—are themselves being reshaped by the rise of ESG investing. The study investigates how smart beta managers can integrate ESG considerations into their investment frameworks without compromising their original financial objectives. Empirical analysis of recent return patterns suggests that investor preferences have shifted toward ESG-aligned assets, indicating that certain sustainability risks are increasingly being priced into markets. This trend provides a rationale for incorporating ESG-based factors into multifactor investment strategies, anticipating the development of ESG-related risk premia. The paper also explores the case of minimum volatility strategies, demonstrating how smart beta managers can mitigate sustainability risks in portfolio construction without altering the fundamental characteristics of their strategies. The findings highlight the evolving role of ESG in factor investing and underscore the need for asset managers to adapt their methodologies to align with sustainability objectives while maintaining financial performance. The study contributes to the ongoing discussion on sustainable finance and offers insights into the integration of ESG factors into quantitative investment strategies.

Tzou and Tseng (2022) [41] explored the impact of AI and Augmented Reality (AR) in the beauty industry, focusing on how these technologies enhance personalization and consumer engagement. The authors highlight that AI and AR are transforming beauty by enabling virtual try-ons, personalized product recommendations, and AI-driven skincare diagnostics. The advancements in smartphone technology have accelerated the adoption of these innovations, allowing consumers to test beauty products virtually before purchase. The study describes key AI and AR applications in the industry, including Estée Lauder's virtual try-on tool that allows users to sample multiple lipstick shades in seconds. The authors emphasize the importance of real-time facial tracking technology, which ensures accurate rendering of virtual cosmetics. Additionally, AI-driven skin-tone detection, such as PerfectCorp's iMatch™ Virtual Shade Expert, enables personalized foundation recommendations based on a database of nearly 90,000 skin tones. AI also plays a crucial role in skin diagnostics by identifying skin conditions like acne, wrinkles, and redness, helping consumers choose appropriate skincare products. The study further discusses AI-powered hair-dye simulations, which allow users to preview hair color effects realistically. The authors argue that personalized AI recommendations are becoming essential for beauty brands, as consumers increasingly seek customized shopping experiences. The study concludes that AI and AR will continue to revolutionize the beauty industry

by improving user experience, increasing personalization, and enhancing consumer confidence in product selection.

Pambudi and Dwinata (2023) [30] investigated the factors influencing customer intention to use AI technology in the beauty industry. The study applied the Technology Readiness Index (TRI), Technology Acceptance Model (TAM), and Theory of Planned Behavior (TPB) to analyze the role of technology readiness, perceived usefulness, perceived ease of use, and subjective norms in customer adoption of AI-driven beauty applications. Data were collected through a survey of 127 respondents who had previously used AI technology in the beauty industry. The results indicated that perceived usefulness did not significantly impact customer intention to use AI technology, whereas perceived ease of use and subjective norms did. Optimism and innovativeness were positively associated with perceived ease of use, while discomfort negatively affected perceived usefulness. Insecurity did not influence perceived usefulness but was negatively correlated with perceived ease of use, suggesting that concerns over data security hinder user adoption. The study also found that subjective norms—particularly social influence—played a significant role in shaping customer intention to use AI-driven beauty tools. The authors concluded that while AI technology enhances personalization and convenience in the beauty industry, companies must address security concerns and ensure user-friendly interfaces to increase adoption. Additionally, leveraging social influence, such as influencer marketing, could effectively encourage customers to engage with AI-powered beauty applications.

Zhu (2024) [47] explores advanced crystallography measurements through directional reflectance microscopy (DRM), a novel optical technique for grain orientation mapping in crystalline solids. The study addresses limitations in traditional diffraction-based methods, which are costly, time-consuming, and require extensive sample preparation. DRM offers a non-destructive and high-throughput alternative by analyzing optical reflectance signals from chemically etched surfaces. The research introduces a physics-based reflectance model, termed dictionary indexing DRM (DI-DRM), which enhances measurement accuracy by comparing experimentally captured reflectance profiles against a precomputed dictionary of simulated signals. This approach improves orientation mapping reliability across various materials and crystal orientations, demonstrating an average measurement error of approximately 3°. The method also exhibits robustness against experimental variations such as noise and surface imperfections. A key application of DI-DRM is its ability to characterize curved surfaces, demonstrated through grain orientation mapping of a nickel-based turbine blade. This advancement highlights DRM's potential for quality control in digital manufacturing. Furthermore, the study explores DRM's capacity to reconstruct 3D grain boundary networks and assess plastic deformation in polycrystalline metals, paving the way for high-throughput mechanical testing. The findings establish DRM as a viable alternative to conventional crystallographic techniques, particularly for large-scale and complex geometries. Future research is recommended to refine DI-DRM for broader industrial adoption and to explore its integration into digital twin models for material characterization.

Moreira (2024) [26] explores the evolving relationship between beauty, technology, and consumer behavior, emphasizing how AI and augmented reality (AR) have reshaped consumer experiences in the beauty industry. The study traces the historical evolution of beauty perceptions to modern trends that prioritize diversity and personalization. AI and AR have significantly influenced retail engagement by offering virtual try-ons (VTO), personalized recommendations, and AI-driven chatbots, which enhance customer satisfaction and brand loyalty. The research, based on empirical data from 230 respondents, investigates consumer perceptions and behaviors related to VTO, AR, and AI-driven digital tools. Findings indicate that VTO accuracy and usability play a crucial role in shaping purchase decisions and consumer trust in product recommendations. Furthermore, interactions with AI-driven chatbots positively correlate with customer satisfaction and long-term brand engagement. AR applications provide immersive experiences that enhance consumer engagement, further supporting the adoption of emerging beauty technologies. The study underscores the transformative impact of AI and AR on consumer expectations and loyalty in the beauty sector. It calls for further research into cross-cultural variations and longitudinal trends in technology adoption, highlighting the need to understand how these digital innovations shape future beauty industry developments.

Methodology

This study employs a qualitative research approach, drawing on an extensive review of secondary data sources, including peer-reviewed journal articles, industry reports, and case studies. The research focuses on understanding how AI is integrated into DRM within the beauty industry, specifically in areas such as predictive analytics, supply chain resilience, cybersecurity, and crisis response. By systematically analyzing existing literature and industry examples, the study identifies key AI-driven strategies used to mitigate risks associated with natural disasters, economic disruptions, public relations crises, and technological vulnerabilities. The collected data is critically examined to highlight both the benefits and limitations of AI applications in DRM, providing a balanced perspective on its effectiveness in ensuring business continuity and resilience.

A thematic analysis is conducted to categorize AI applications based on their role in disaster prevention, preparedness, response, and recovery. This analytical approach enables a structured evaluation of AI's impact on industry stability and risk mitigation strategies. Additionally, real-world cases of AI implementation in beauty and adjacent industries are assessed to draw practical insights. The study also considers ethical concerns, including data privacy, algorithmic biases, and regulatory challenges, to provide a comprehensive discussion of AI's role in DRM. By synthesizing findings from multiple sources, the research offers a holistic understanding of how AI technologies are transforming risk management practices in the beauty sector, ensuring adaptability and long-term sustainability.

AI Applications in DRM for the Beauty Business

AI is increasingly recognized as a pivotal tool in enhancing DRM across various industries, including the beauty sector. Its applications span predictive analytics, supply chain optimization, crisis response, and cybersecurity, all of which

contribute to building resilience against potential disruptions.

In the realm of predictive analytics, AI systems are employed to forecast natural disasters and economic downturns that could impact beauty businesses. By analyzing vast datasets encompassing weather patterns, geological data, and economic indicators, AI models can predict events such as hurricanes, earthquakes, or financial crises (Sun *et al*., 2020) [39].

Supply chain management within the beauty industry also benefits significantly from AI integration. AI-driven predictive analytics facilitate efficient inventory planning and demand forecasting, allowing companies to maintain optimal stock levels and reduce waste. By analyzing consumer behavior, market trends, and external factors, AI can predict product demand with greater accuracy, ensuring that beauty products are available when and where they are needed. This optimization not only enhances customer satisfaction but also fortifies the supply chain against disruptions caused by unforeseen events (Intellico Solutions, 2024) [15].

AI-driven platforms ensure that customer interactions remain seamless during disruptions, thereby preserving brand loyalty. Moreover, AI can assist in automating business insurance claims processing, expediting recovery efforts post-disaster (Vogue Business, 2025) [42].

Cybersecurity is another critical area where AI contributes to DRM in the beauty industry. With the increasing digitalization of beauty services and e-commerce platforms, the risk of cyber threats has escalated. AI algorithms enhance cybersecurity measures by detecting and preventing cyberattacks, such as data breaches or phishing attempts, thereby safeguarding sensitive customer information and maintaining the integrity of online beauty businesses (Sun *et al*., 2020) [39].

In today's globalized economy, businesses face a multitude of risks, from economic fluctuations and regulatory changes to technological disruptions and supply chain crises. However, the single greatest threat to industries and businesses in the contemporary world is competition. As markets become increasingly saturated and digital transformation lowers barriers to entry, businesses are under relentless pressure to differentiate themselves, maintain profitability, and sustain long-term growth. The nature of competition has evolved significantly, shifting from localized market rivalries to a highly interconnected global contest, where firms must constantly innovate or risk obsolescence. Research indicates that AI serves as a transformative force reshaping global power dynamics, with emerging economies viewing it as an opportunity for competitive advantage despite regulatory challenges (Rahmatian, 2025) [32].

One of the primary reasons competition poses such a severe threat is the speed at which new entrants can disrupt established industries. Critical perspectives highlight AI as a contested epistemic force that embodies structural asymmetries while simultaneously offering opportunities for local innovation and resistance (Hosseini & Sakhaei, 2025) [13]. The rise of technology-driven startups, particularly in sectors such as e-commerce, fintech, and artificial intelligence, has led to an unprecedented level of market turbulence. Companies that once enjoyed monopolistic or oligopolistic dominance now find themselves struggling against lean, agile competitors that leverage digital tools, automation, and data analytics to deliver superior products and services at lower costs. Established businesses, burdened by legacy systems and bureaucratic inertia, often find it challenging to adapt quickly enough, leading to their decline or displacement.

Another significant dimension of competition stems from globalization. Businesses are no longer just competing with local or national rivals; they must contend with international corporations that benefit from economies of scale, cost-effective labor, and access to broader markets. For example, manufacturing industries in Western nations have faced intense competition from countries such as China and India, where labor costs are significantly lower. Similarly, tech firms in the United States are in constant rivalry with emerging players from Asia and Europe, driving an innovation race that leaves little room for stagnation. The consequence of this relentless global competition is often margin compression, forcing businesses to either lower their prices, reduce costs, or find new value propositions to remain viable (D'Aveni, 2010) [8].

Moreover, competition in the digital age has shifted from merely producing better products to capturing consumer attention in an increasingly fragmented media landscape. With the rise of social media, digital marketing, and personalized advertising, businesses must now compete not only in terms of quality and pricing but also in brand visibility and consumer engagement. The attention economy has placed significant pressure on businesses to continuously adapt their marketing strategies, invest in data-driven customer insights, and navigate ever-changing consumer preferences. Companies that fail to leverage these tools effectively often find themselves overshadowed by competitors who do (Baeza-Yates & Fayyad, 2022) [3].

Additionally, as competition intensifies, businesses must allocate substantial resources to research and development (R&D) to stay ahead. Innovation has become a key determinant of survival, with industries such as pharmaceuticals, automotive, and technology witnessing astronomical R&D expenditures. However, the need for continuous innovation presents financial risks, as not all investments yield profitable outcomes. Even companies that manage to introduce groundbreaking technologies often find their advantages short-lived, as competitors swiftly replicate or improve upon their innovations.

While factors such as economic instability, regulatory burdens, and supply chain disruptions undoubtedly pose significant risks, they tend to be cyclical or industry-specific. Competition, on the other hand, is a universal and perpetual force that affects every sector and business, demanding constant vigilance, agility, and reinvention. Firms that fail to acknowledge and proactively respond to the pressures of competition risk irrelevance in an increasingly unforgiving market landscape.

With the rapid rise of social media as the primary platform for beauty trends, consumer engagement, and brand marketing, AI offers manufacturers unprecedented opportunities to analyze global conversations and identify emerging markets. Research on media organizations reveals significant disparities in AI adoption based on organizational type and demographics, with digital-native companies and younger professionals showing higher digital adaptability (Khodabin *et al*., 2023) [20]. By leveraging AI-driven analytics, beauty business manufacturers can track consumer sentiment, discover untapped demand, and make

data-driven decisions on where to expand their products and services (Treves, Ritala & Aaltonen, 2025) [40]. Social media platforms like Instagram have a profound impact on user behavior and well-being. As Zamani *et al*. (2021) [45] found, while excessive use for entertainment can negatively affect social health, using platforms like Instagram for learning, communication, and self-expression can enhance social integration and well-being. In the beauty industry, where social media drives trends, AI-powered sentiment analysis can help brands tailor strategies, predict consumer behavior, and mitigate risks, ensuring a more resilient brand image. However, beyond technological tools, psychological factors such as personality traits also play a critical role in shaping consumer behavior and social interactions. Jamali *et al*. (2022) [16] highlight that these factors significantly influence social incompatibility and behavioral outcomes, which can impact how consumers engage with brands and respond to marketing strategies. By integrating psychological insights into AI-driven approaches, beauty brands can better understand and address the underlying motivations of their consumers, fostering deeper connections and ensuring long-term brand loyalty.

One of the most effective ways AI helps beauty businesses identify new markets is through social media sentiment analysis. AI-powered tools can scan millions of posts, comments, and reviews across platforms like Instagram, TikTok, YouTube, and Twitter, extracting insights about consumer preferences and emerging beauty trends. By analyzing this data, manufacturers can detect where certain products, such as organic skincare, vegan cosmetics, or K-beauty products, are gaining popularity. For example, if AI identifies a growing demand for cruelty-free makeup in regions like Southeast Asia or Latin America, companies can prioritize these markets for product launches and marketing campaigns.

AI also enables beauty businesses to analyze demographic and geographic data from social media. Advanced algorithms can categorize user-generated content based on location, age, gender, and purchasing behaviors, allowing manufacturers to pinpoint regions with the highest engagement for specific beauty trends. For instance, if AI detects an increasing interest in anti-aging serums among consumers in Middle Eastern countries, manufacturers can tailor their marketing strategies and product offerings to cater to this demand. This level of precision allows companies to allocate resources efficiently, ensuring they enter markets with a strong likelihood of success.

Furthermore, AI-driven trend forecasting plays a crucial role in identifying new opportunities for market expansion. Machine learning models can predict which beauty trends will gain traction in different parts of the world by analyzing historical data, influencer content, and real-time consumer interactions. This allows beauty manufacturers to stay ahead of the curve, positioning their products in regions where demand is expected to rise. For example, AI may predict that minimalist skincare routines will become increasingly popular in Europe, prompting brands to introduce streamlined product lines that align with this trend before competitors do.

Another advantage AI provides is competitive analysis. By monitoring social media conversations about competitors, AI can identify gaps in the market that beauty brands can capitalize on. If consumers in a specific region frequently express dissatisfaction with the limited availability of certain beauty products, manufacturers can step in to fill this void. AI can also analyze the performance of rival brands, helping businesses refine their pricing, packaging, and promotional strategies to gain a competitive edge in new markets.

Additionally, AI-powered chatbots and social listening tools allow beauty brands to engage directly with consumers across different regions, gathering real-time feedback and preferences. This not only helps in market identification but also fosters brand loyalty by demonstrating responsiveness to consumer needs. AI can even translate multilingual social media content, ensuring that beauty manufacturers understand consumer sentiment across diverse linguistic and cultural landscapes.

One of the most valuable applications of AI in the beauty industry is sentiment analysis, which allows manufacturers to understand how consumers perceive their products and pricing. AI-powered tools scan social media platforms like Instagram, TikTok, Twitter, and YouTube, processing millions of posts, comments, and reviews to extract consumer opinions. By identifying recurring themes in discussions—such as dissatisfaction with certain ingredients, demand for specific product features, or price sensitivity—brands can make targeted improvements to their offerings. For example, if AI detects a growing consumer preference for fragrance-free skincare due to allergy concerns, manufacturers can adjust their formulations accordingly to appeal to this segment.

AI also enables beauty businesses to conduct real-time competitor analysis, helping them refine their pricing strategies to remain attractive to consumers without eroding profitability. Machine learning algorithms can track how consumers react to price changes across different brands, allowing companies to identify optimal price points for their products. If AI reveals that a competitor's high-end serum is frequently criticized for being overpriced while a mid-range alternative is gaining popularity, beauty manufacturers can adjust their pricing to better match customer expectations. This dynamic pricing strategy ensures that businesses remain competitive while maximizing revenue.

Another significant advantage AI provides is predictive trend analysis. By examining past social media trends and current engagement patterns, AI can forecast which beauty products will become popular in the near future. This helps manufacturers refine their product lines before trends peak, allowing them to meet consumer demand ahead of competitors. For example, AI may predict an upcoming surge in demand for blue-light protection skincare due to increased screen time in modern lifestyles. A beauty brand that acts on this insight early can launch relevant products before the market becomes oversaturated, giving them a first-mover advantage.

Moreover, AI-driven personalization plays a crucial role in product refinement and pricing optimization. By analyzing consumer behavior, purchase history, and social media interactions, AI can help brands tailor their products to different customer segments. For instance, data may reveal that Gen Z consumers prefer bold, experimental makeup at an affordable price, while older demographics prioritize anti-aging formulations with premium ingredients. Beauty manufacturers can use these insights to develop tiered pricing structures and specialized product lines that cater to diverse audiences, reducing the risk of losing customers to competitors who offer more personalized options. Additionally, gamification mechanics, such as badges and

rewards, can further enhance consumer engagement with AI-powered tools like virtual try-ons and personalized recommendations. As Bagheri *et al*. (2022) [4] found, gamification improves interaction and loyalty, making it a valuable strategy for beauty brands to strengthen their market position and boost customer satisfaction. Moreover, understanding gender-specific communication patterns is equally important for effective personalization. As Mahmoodi-Bakhtiari and Dehghani (2014) [223] found, male and female authors exhibit distinct writing styles, reflecting broader gender-specific communication patterns. In the beauty industry, where AI-driven tools like virtual try-ons and personalized recommendations are increasingly used, recognizing these gender nuances is crucial. By tailoring AI systems to reflect these differences, beauty brands can further enhance customer engagement and satisfaction, ensuring their products resonate with diverse audiences and align with evolving consumer expectations.

AI also improves supply chain efficiency, ensuring that beauty businesses produce the right quantities of products at the right time. By analyzing social media demand signals, AI can prevent overproduction of less popular items and focus resources on high-demand products. This reduces costs, minimizes waste, and allows brands to price their products more competitively without compromising profitability (Nichifor *et al*., 2023) [28].

AI-powered social listening tools enable beauty manufacturers to detect potential scandals before they spiral out of control. These systems continuously scan social media platforms, forums, and news websites, analyzing text, images, and even videos for negative sentiment, trending hashtags, and viral complaints. Unlike traditional monitoring methods, AI can process vast amounts of data in real-time, identifying emerging issues as soon as they gain traction. For instance, if a product causes allergic reactions and multiple users begin sharing images and warnings on Twitter, AI can immediately flag the trend, allowing the company to assess the situation and prepare a response before mainstream media amplifies the controversy.

By leveraging natural language processing (NLP), AI can also categorize complaints by severity, helping brands prioritize their responses. A few scattered negative reviews may not warrant urgent action, but a surge in posts accusing a company of using harmful chemicals, for example, signals a major crisis. AI can distinguish between isolated incidents and widespread movements, enabling businesses to allocate resources efficiently when managing public relations disasters (Imran *et al*., 2020) [14].

When a scandal erupts, understanding the core issue is crucial for crafting an appropriate response. AI-driven sentiment analysis helps beauty manufacturers decode consumer emotions, identifying the key themes fueling outrage. If consumers are protesting due to an offensive advertisement, AI can analyze feedback to determine whether the backlash stems from cultural insensitivity, gender stereotyping, or other problematic messaging. This prevents companies from issuing generic apologies that fail to address the heart of the controversy.

Moreover, AI can track how discussions evolve over time. Public sentiment is dynamic, and an initial complaint may morph into broader criticisms of a brand's ethics or business practices. For example, a single instance of product mislabeling might escalate into widespread distrust about a brand's transparency. By using AI to map the progression of negative discourse, companies can respond in a way that addresses not only the immediate scandal but also any underlying systemic concerns.

Once the root cause of a scandal is identified, beauty businesses must respond strategically to control the narrative. AI can assist in drafting crisis communication messages that align with public sentiment. Some AI tools use past crisis data to predict which types of responses are most effective in diffusing tension. If previous industry scandals show that consumers respond positively to direct, transparent explanations rather than vague PR statements, AI can recommend a similar approach.

Additionally, AI can analyze successful damage-control strategies from other brands. If a competitor faced a similar backlash and managed to recover public trust through influencer partnerships, corporate responsibility initiatives, or product reformulation, AI can suggest similar strategies tailored to the current crisis. This allows businesses to learn from industry precedents instead of improvising under pressure.

In beauty industry scandals, influencers and media coverage often play a crucial role in shaping public perception. AI can track which influencers and journalists are discussing the controversy and determine whether their sentiment is neutral, supportive, or highly critical. This information helps brands decide who to engage with and how to shape their messaging.

For instance, if AI identifies that beauty influencers are fueling the boycott movement, the brand can focus on damage control within that community by reaching out with clarifications or offering direct dialogue. On the other hand, if AI detects that certain journalists are publishing inaccurate information, the company can issue factual corrections to limit misinformation. AI-driven media tracking also helps brands measure whether their response strategies are working by monitoring shifts in sentiment over time.

Beyond responding to immediate crises, AI enables beauty manufacturers to prevent similar scandals in the future by identifying patterns in consumer complaints. If a particular ingredient frequently sparks backlash, AI can alert product development teams to find safer alternatives. If pricing controversies often lead to boycotts, AI can recommend adjustments to promotional strategies. By learning from past mistakes and consumer reactions, brands can proactively refine their practices to align with evolving market expectations. However, successful AI implementation requires addressing significant gaps in AI literacy across different educational contexts and establishing standardized frameworks for effective technology adoption (Khodabin *et al*., 2022) [19].

AI-powered reputation management also includes predictive analytics. By analyzing historical data, AI can forecast potential risks before they explode into full-blown crises. For example, if AI detects rising concerns about sustainability in beauty products, companies can take preemptive steps to improve eco-friendly practices and communicate these efforts transparently before customers start protesting.

Conclusion

The integration of AI in Disaster Risk Management within the beauty industry has transformed industry solutions to mitigating risks and ensuring operational resilience. AI-

driven predictive analytics enable businesses to anticipate and respond proactively to natural disasters, economic disruptions, and supply chain vulnerabilities, thereby reducing financial losses and enhancing consumer trust. Moreover, AI enhances supply chain optimization, cybersecurity, and crisis communication, allowing beauty brands to navigate disruptions efficiently while maintaining business continuity. The ability of AI to process vast amounts of real-time data ensures that businesses can make informed decisions, improving their adaptability in an increasingly volatile global market. However, despite its numerous advantages, the widespread adoption of AI in DRM also introduces challenges, including data privacy concerns, ethical considerations, and the need for robust cybersecurity measures to safeguard sensitive consumer and business information.

The beauty industry continues to evolve and embrace digital transformation, and therefore, the role of AI in DRM will become increasingly vital. Companies must prioritize ethical AI deployment, ensuring compliance with regulatory frameworks while addressing algorithmic biases and transparency concerns. Future research should explore ways to refine AI applications in DRM, particularly in developing standardized risk assessment models tailored to the unique challenges of the beauty sector. Furthermore, fostering collaboration between AI developers, industry leaders, and policymakers will be crucial in enhancing AI-driven DRM strategies. The beauty industry can leverage AI responsibly and innovatively and hence, it can not only mitigate disaster-related risks but also improve long-term sustainability and resilience against unforeseen disruptions.

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