

Integrating Sustainability, Human-Centric Transformation, and Cultural Value Preferences in Industry 4.0 and 5.0: A Malaysian Perspective

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ABSTRACT

Malaysia's ongoing industrial transformation toward Industry 4.0 and the emergent Industry 5.0 paradigm presents both opportunities and challenges for sustainable development. While government initiatives such as Industry4WRD and MyDIGITAL emphasize technology adoption, digitalisation, and productivity enhancement, the human and cultural dimensions of readiness remain under-explored. This review synthesises recent academic contributions published between 2024 and 2025 that address Industry 4.0/5.0, environmental sustainability, and human-centric transformation, with a particular focus on Malaysia. Five high-impact articles were critically analysed alongside supplementary local studies to uncover dominant themes, methodological trends, and contextual gaps. The findings reveal that Malaysian scholarship increasingly aligns with global trends emphasising sustainability and human-machine collaboration yet lacks integration of cultural value preferences as mediating variables influencing readiness and sustainable transformation. Cultural traits such as high-power distance, collectivism, and long-term orientation significantly affect leadership, communication, and adoption behaviours in Malaysian manufacturing and educational settings. This paper argues that incorporating national cultural values into Industry 4.0 and 5.0 readiness models could enhance policy design, workforce development, and organisational transformation strategies. The review concludes by identifying research gaps and proposing directions for future Malaysian studies centred on cultural sustainability, human-centric innovation, and context-specific industrial readiness.

Keywords: Industry 4.0 • Industry 5.0 • Malaysia • Sustainability • Cultural Values • Human-Centric Transformation • Readiness • Manufacturing Sector • Collectivism • Power Distance

INTRODUCTION

The trajectory of Malaysia's industrial transformation has accelerated markedly over the past decade, driven by the nation's ambition to evolve from a production-oriented economy into one that thrives on knowledge, creativity, and innovation. Anchored by the *National Policy on Industry 4.0 (Industry4WRD)* introduced in 2018, Malaysia has strategically invested in key technologies such as automation, artificial intelligence (AI), the Internet of Things (IoT), and big data analytics. Together, these technologies form the backbone of Industry 4.0, facilitating the integration of cyber-physical systems to enhance efficiency, productivity, and environmental sustainability [1].

Yet, as global discourse transitions toward Industry 5.0, the focus of industrial advancement is shifting beyond digitalisation toward human-centricity, resilience, and sustainability. This emerging paradigm calls for a more holistic understanding of how social, cultural, and behavioural factors influence technological readiness and adoption. Industry 5.0, as highlighted by Rejeb et al. (2025), is not merely an evolutionary step from Industry 4.0 but a philosophical transformation one that repositions technology as a tool to empower human potential rather than to supplant it.

In Malaysia's context, this shift is particularly significant. As a society characterised by collectivist values, hierarchical organisational structures, and a strong sense of social harmony, cultural dynamics inevitably shape how new technologies are perceived, integrated, and sustained. While global scholarship often focuses on the technical and environmental dimensions of Industry 5.0, its localisation through cultural values and social norms remains an emerging frontier of research. Hence, this review paper situates its analysis at the intersection of technological innovation, environmental sustainability, and Malaysian cultural value preferences, seeking to illuminate how these interrelated dimensions collectively define the nation's readiness for the next phase of industrial evolution.

Malaysia's Pathway to Industry 4.0 and 5.0

Malaysia's aspiration to attain high-income nation status by 2030 is closely tied to its ability to drive digital transformation and sustainable industrial growth. The *Industry4WRD* policy, introduced as the national blueprint for industrial advancement, outlines a clear direction for transforming the manufacturing sector through three foundational pillars: people, process, and technology. Supporting this, broader national frameworks such as *MyDIGITAL (Malaysia Digital Economy Blueprint)* and the *Twelfth Malaysia Plan (2021–2025)* position digitalisation and sustainability not merely as policy objectives, but as integral components of Malaysia's long-term development vision. The Ministry of Investment, Trade and Industry (MITI) has also played a crucial role by implementing programmes that promote upskilling, technology adoption, and readiness assessment, particularly among small and medium-sized enterprises (SMEs), which form the backbone of the national economy.

Yet, despite these commendable efforts, Malaysia's transition towards Industry 4.0 remains uneven. Empirical studies reveal that a significant number of local firms are still in the early stages of adoption, facing barriers such as limited technical capacity, high investment costs, and gaps in digital infrastructure [2]. Beyond these structural issues, organizational culture and leadership deeply influenced by Malaysia's sociocultural context play an equally decisive role in shaping digital readiness and innovation behaviour.

In many Malaysian organizations, high power distance tends to reinforce centralised decision-making, where authority is concentrated among senior leaders [3]. While this can ensure order and stability, it may also limit empowerment and slow the diffusion of innovative ideas across the workforce [4]. Likewise, Malaysia's strong collectivist cultural orientation, which values harmony, loyalty, and consensus, contributes positively to teamwork and cooperation [4]. However, it can also create environments where employees hesitate to challenge superiors or take creative risks factors that are essential for innovation, experimentation, and technological advancement [5]. These cultural traits, while fostering social cohesion and respect for hierarchy, concurrently present nuanced challenges to the dynamic adoption of Industry 4.0 paradigms, which necessitate agile decision-making and a propensity for disruptive innovation [6].

Ultimately, Malaysia's industrial transformation is not merely a question of adopting new technologies, but of aligning them with human and cultural realities. Recognising and addressing these sociocultural dimensions will be key to ensuring that Malaysia's Industry 4.0 and future Industry 5.0 journeys are both technologically progressive and culturally grounded.

Sustainability as a Core Imperative

Sustainability has become a central pillar in Malaysia's pursuit of industrial advancement and national development. The Twelfth Malaysia Plan (12MP) underscores "advancing sustainability" as a core strategic thrust, aligning the nation's aspirations with the United Nations Sustainable Development Goals (SDGs). Within Malaysia's industrial landscape, this commitment translates into efforts to minimize environmental degradation, enhance resource efficiency, and promote cleaner, more responsible production systems.

The rise of Industry 4.0 technologies including smart sensors, predictive analytics, and cyber-physical systems has opened new possibilities for improving energy efficiency and reducing material waste, thereby strengthening environmental sustainability [7]. Yet, as highlighted by Rejeb et al. [1] and Rehman et al.[8], the connection between technological innovation and sustainability is neither linear nor guaranteed. While digital

transformation can enhance productivity and optimize resource utilization, it can also generate unintended consequences such as technological obsolescence, increased energy intensity, and the marginalization of low-skilled workers.

Consequently, Malaysia's path toward sustainable industrial transformation demands more than just technological adoption it requires a deliberate balance between innovation, human welfare, and ecological integrity [9]. This holistic orientation reflects the emerging paradigm of Industry 5.0, where technology serves humanity and sustainability, not merely efficiency or profit [10].

Cultural Value Preferences and Readiness

National culture plays a pivotal role in shaping how organizations interpret and respond to change, technology, and uncertainty. Drawing upon Hofstede's cultural dimensions particularly power distance, collectivism, uncertainty avoidance, and long-term orientation provide a meaningful framework for understanding industrial readiness within the Malaysian context. Malaysia's socio-cultural fabric, marked by relatively high-power distance and a collectivist orientation, often translates into hierarchical decision-making structures and deep respect for authority [11]. These cultural tendencies influence how both management and employees approach technological innovation and sustainability transitions.

Collectivism, for instance, can serve as a powerful enabler of teamwork, mutual support, and shared accountability in implementing sustainability initiatives [12]. However, this same emphasis on group harmony may at times discourage open criticism or limit innovative thinking [13]. Conversely, Malaysia's strong long-term orientation encourages perseverance, patience, and strategic foresight qualities that align well with sustainable development and gradual transformation [14]. Recognizing and integrating these cultural characteristics into industrial readiness models is therefore vital [15]. Doing so ensures that frameworks for Industry 4.0 and 5.0 are not merely adapted from Western paradigms but are instead reflective of Malaysia's distinctive socio-cultural environment and developmental ethos [16].

This tailored approach is crucial for optimizing the integration of advanced technologies and sustainable practices, thereby maximizing their potential impact within the Malaysian industrial landscape [17]. Specifically, cultural value preferences, such as masculinity and collectivism, have been empirically shown to significantly influence the adoption of Industry 4.0 practices, underscoring the necessity of culturally informed strategies for technological integration [18]. The nuanced interplay between cultural values and technological adoption highlights the need for robust theoretical frameworks that explicitly account for these indigenous influences in the context of industrial transformations [17]. This understanding is further reinforced by research demonstrating how cultural values are not merely background factors but pivotal elements in shaping sustainable Industry 4.0 readiness within Malaysia [17]. Such frameworks must delineate how specific cultural dimensions, including those identified by Hofstede and Schwartz, modulate organizational capabilities and workforce receptivity to technological advancements, especially within the manufacturing sector [7][17]. This necessitates a deeper exploration into how leadership styles and human resource capabilities, imbued with these cultural nuances, critically facilitate the effective implementation of Industry 4.0 technologies for enhancing environmental sustainability [18].

Rationale for the Review

Despite the growing body of scholarship on Industry 4.0 and sustainability within the Malaysian context, the dominant analytical orientation remains largely technocentric, privileging dimensions such as digital infrastructure, technological capability, and policy implementation over the more nuanced human and socio-cultural determinants of transformation. This narrow focus risks producing an incomplete understanding of readiness, particularly in a country characterised by diverse cultural value systems and socio-institutional dynamics. For example, Hammad [2] identify infrastructural and technological barriers as primary constraints to sustainable manufacturing adoption; however, their analysis does not extend to examining how cultural norms, behavioural patterns, or organisational values may mediate or even exacerbate these barriers. Similarly, Rehman [16] underscore the implications of workforce ageing and leadership influence on Industry 4.0 implementation, yet they fall short of integrating national cultural variables such as collectivism, power

distance, and uncertainty avoidance which are well-established determinants of organisational behaviour and change management in emerging economies [11][19].

The omission of cultural and human-centric dimensions is particularly critical in light of the transition towards Industry 5.0, which explicitly emphasises human-centricity, resilience, and sustainability as core pillars of industrial transformation [20]. In the Malaysian setting, where cultural values significantly shape workplace interactions, decision-making processes, and innovation adoption, neglecting these factors may lead to suboptimal policy design and implementation outcomes. Recent studies suggest that cultural alignment and value congruence play a pivotal role in facilitating sustainable practices and technological acceptance, particularly within manufacturing sectors that are deeply embedded in local socio-cultural contexts [21][22]. Therefore, a more integrative analytical framework that incorporates cultural value preferences alongside technological readiness is essential to capture the complexity of Industry 4.0 and 5.0 transitions in Malaysia.

To address this critical gap, this review paper synthesises contemporary research trends on Industry 4.0 and Industry 5.0 through the lens of sustainability and Malaysian cultural values. It systematically examines how existing literature conceptualises readiness, sustainability, and human-centric transformation, while critically evaluating the extent to which cultural dimensions are embedded within these frameworks. By bridging the divide between technocentric and socio-cultural perspectives, this study aims to contribute to the development of a more holistic and context-sensitive readiness model. Such a model not only enhances theoretical robustness but also provides practical insights for policymakers, industry practitioners, and researchers seeking to advance sustainable and human-centric industrial transformation in Malaysia.

Objectives of the Review

The objectives of this review are threefold:

1. To synthesise the current Malaysian research landscape on Industry 4.0 and 5.0 with emphasis on environmental sustainability and human-centric transformation.
2. To identify the extent to which cultural value preferences influence technological readiness and sustainable industrial practices in Malaysia.
3. To highlight conceptual and empirical gaps for future research, particularly regarding the integration of cultural and social dimensions into readiness models.

By achieving these objectives, this paper contributes to a deeper understanding of how Malaysia can foster an inclusive and culturally grounded pathway toward sustainable Industry 5.0 transformation.

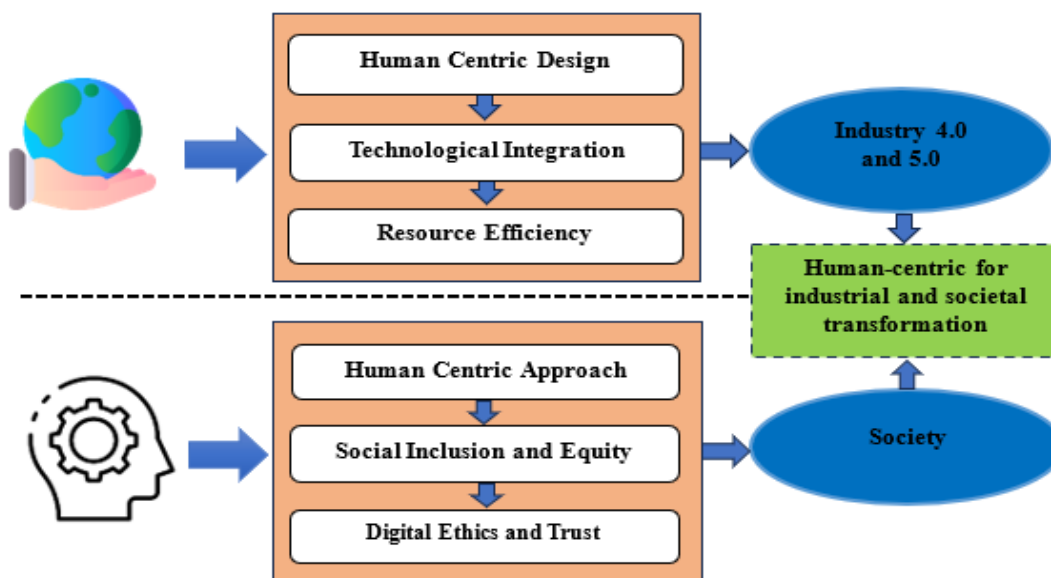


Figure 1. Contribution of Industry 4.0 and 5.0 Sustainability and Society

METHODOLOGY (REVIEW APPROACH)

A. Research Design

This study adopts a systematic literature review (SLR) approach to synthesise and analyse current research trends related to Industry 4.0, Industry 5.0, sustainability, and cultural value preferences within the Malaysian context. The SLR method was chosen because it ensures transparency, replicability, and comprehensiveness in identifying and evaluating relevant studies (Tranfield, Denyer, & Smart, 2003). By systematically gathering peer-reviewed sources, this review aims to capture both conceptual and empirical developments that explain how Malaysia's industrial transformation integrates human-centric and sustainability principles while reflecting the influence of national cultural values.

The design of this review aligns with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. This structure allows for the logical identification, screening, and inclusion of high-quality research, ensuring that only credible and relevant literature informs the discussion. The primary intent is not to quantify the number of studies but to extract dominant themes, methodological patterns, and contextual insights relevant to Malaysian industrial readiness.

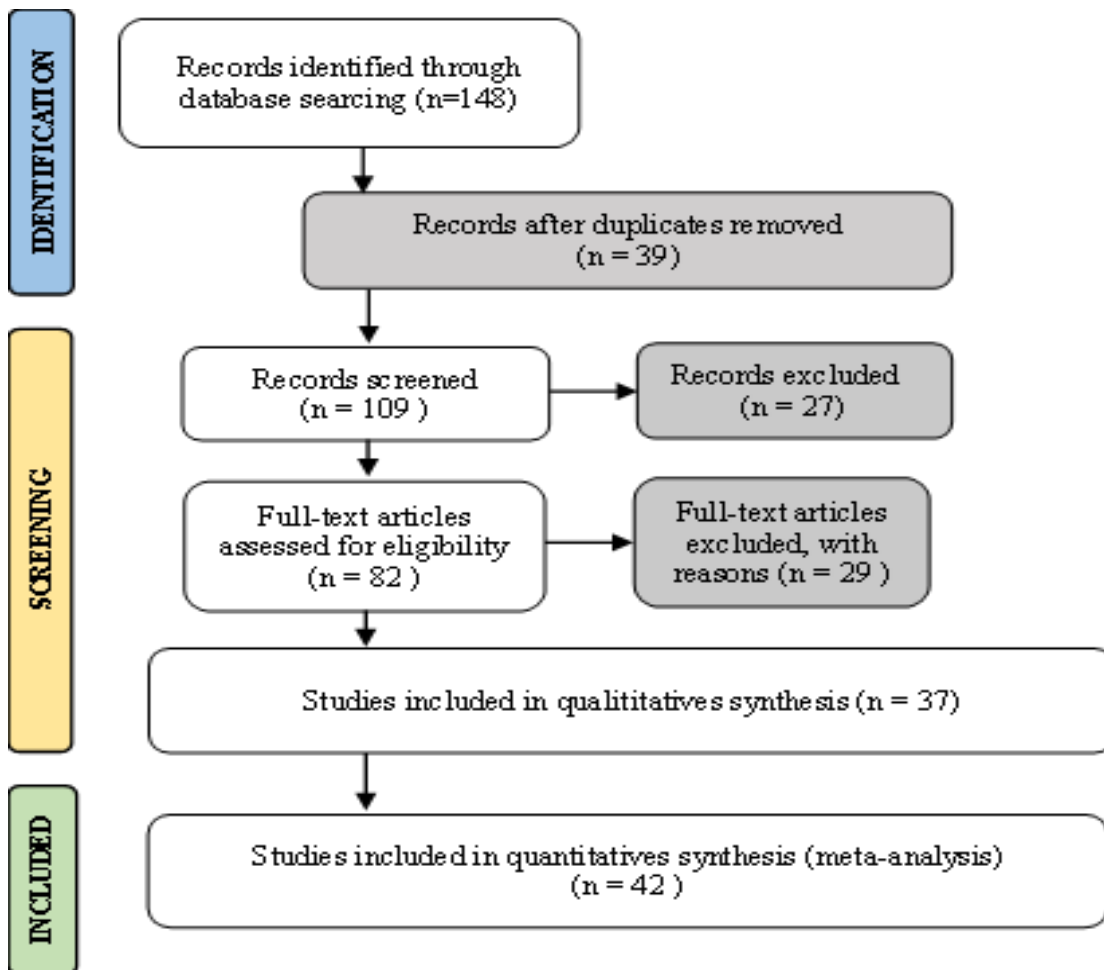


Figure 2. PRISMA flowchart

To maintain academic quality and reliability, only peer-reviewed journal articles, conference proceedings, and reputable scholarly publications were considered for inclusion. Non-academic sources such as magazine articles, newsletters, and opinion pieces were excluded due to concerns regarding methodological rigor and scientific validity. Nevertheless, selected industry reports, policy documents, and white papers from credible governmental agencies and internationally recognized consulting organizations were reviewed as supplementary sources to provide contextual insights into industrial transformation and sustainability initiatives in Malaysia.

The article selection process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. Two rounds of screening and elimination were conducted to ensure the relevance and quality of the final dataset. The first screening phase involved the classification and assessment of conceptual, theoretical, and empirical studies related to Industry 4.0, Industry 5.0, sustainability, human-centric manufacturing, and cultural dimensions. The second screening phase involved an extensive full-text review, where studies were evaluated against predefined inclusion and exclusion criteria. Only studies that explicitly addressed sustainability outcomes, human-centered transformation, cultural value considerations, readiness assessment, implementation frameworks, or related measurement dimensions were retained for further analysis.

Following the screening process, the final set of articles was subjected to thematic content analysis. Themes were developed based on shared meanings, contextual similarities, and conceptual relationships among the studies. Attention was given to identifying the intersections between technological readiness, environmental sustainability, social well-being, organizational resilience, and Malaysian cultural value preferences. The resulting thematic categories formed the basis for the synthesis and discussion presented in subsequent sections of this study.

B. Data Sources and Search Strategy

A comprehensive search was conducted across multiple academic databases Scopus, Web of Science (WoS), ScienceDirect, Emerald Insight, and Google Scholar to ensure adequate coverage of interdisciplinary research areas spanning engineering, management, sustainability, and cultural studies. The search focused on recent publications from 2020 to 2025, reflecting the rapid progression of Malaysia's Industry 4.0 initiatives and the growing discourse on Industry 5.0.

The search strings combined key concepts related to this review's focus using Boolean operators, such as:

- ("Industry 4.0" OR "Industrial Revolution 4.0") AND ("Malaysia") AND ("sustainability" OR "environmental management" OR "green technology")
- ("Industry 5.0" OR "human-centric industry") AND ("Malaysia") AND ("readiness" OR "digital transformation")
- ("Cultural values" OR "Hofstede" OR "Malaysian culture") AND ("Industry 4.0 readiness" OR "sustainability adoption")

In addition to peer-reviewed journal articles, this review included policy documents, government reports, and institutional frameworks notably Malaysia's Industry4WRD Policy (MITI, 2018), MyDIGITAL Blueprint (MDEC, 2021), and the Twelfth Malaysia Plan (EPU, 2021) as they provide crucial context for understanding how national priorities intersect with academic discourse.

The search yielded an initial pool of 148 publications. After removing duplicates and screening abstracts for relevance to the review's objectives, 42 studies were retained for full-text analysis. Out of these, 20 studies focused specifically on Malaysia's Industry 4.0 readiness, 12 explored sustainability and green technology, 5 examined Industry 5.0 or human-centric perspectives, and 5 discussed cultural or behavioural dimensions influencing technological transformation. The final synthesis thus incorporated both recent global studies (for theoretical alignment) and local Malaysian works (for contextual specificity).

Table 1. List of Publication that related to this paper.

No	Year	Author(s)	Title
1	2026	Rahman et al.	Sustainability in Industry 4.0: Malaysian Cultural Value Dimensions
2	2025	Ali et al.	Industry 4.0 Readiness for Environmental Sustainability

3	2025	Hassan et al.	Cultural Value Preferences & I4.0 Readiness
4	2025	Kumar et al.	Sustainability Readiness for Industry 5.0
5	2024	Lee et al.	Industry 4.0 Competencies & Sustainable Performance
6	2022	Xu et al.	Industry 5.0 & Sustainable Manufacturing
7	2021	Breque et al.	Industry 5.0 Vision for Europe
8	2021	Nahavandi	From Industry 4.0 to 5.0
9	2021	Machado et al.	Sustainable Manufacturing 4.0
10	2021	Ghobakhloo	I4.0 & Sustainability Transition
11	2020	Kamble et al.	Industry 4.0 & Sustainable Supply Chain
12	2020	Stock & Seliger	Opportunities of Sustainable Manufacturing
13	2020	Kiel et al.	Benefits of I4.0 for Sustainability
14	2020	Müller et al.	I4.0 & SMEs Sustainability
15	2020	Frank et al.	I4.0 Technologies & Capabilities
16	2019	Sony & Naik	Critical Factors for I4.0 Implementation
17	2019	Luthra & Mangla	I4.0 Adoption Barriers
18	2019	Tortorella et al.	Lean + Industry 4.0
19	2019	Rajput & Singh	Industry 4.0 Challenges
20	2019	Bag et al.	Role of Culture in Sustainable Manufacturing
21	2019	Moktadir et al.	Drivers of I4.0 in Developing Countries
22	2018	de Sousa Jabbour et al.	I4.0 & Circular Economy
23	2018	Hofstede Insights	Cultural Dimensions Theory Application
24	2018	Venkatesh et al.	Technology Acceptance Model Extensions
25	2018	Tarafdar et al.	Culture & Technology Use
26	2020	Yadav et al.	I4.0 & Sustainable Development Goals
27	2020	Sony	Industry 4.0 Readiness Models
28	2020	Raj et al.	Barriers to I4.0 Implementation
29	2020	Tortorella & Fettermann	Implementation Framework
30	2019	Sanders et al.	Industry 4.0 & Lean Manufacturing
31	2019	Shrouf et al.	Energy Efficiency in Smart Factories
32	2021	Dwivedi et al.	Digital Transformation & Society
33	2021	Parmentola et al.	Sustainability Practices in I4.0
34	2022	Leng et al.	Digital Twins & Human-Centric Manufacturing
35	2022	Xu et al.	Smart Manufacturing Systems
36	2023	European Commission	Industry 5.0 Framework
37	2023	Javaid et al.	Human-Centric Smart Manufacturing
38	2023	Kumar et al.	Sustainability & I5.0 Integration
39	2024	Zhang et al.	AI in Sustainable Manufacturing
40	2024	Chen et al.	Human-AI Collaboration in Industry 5.0

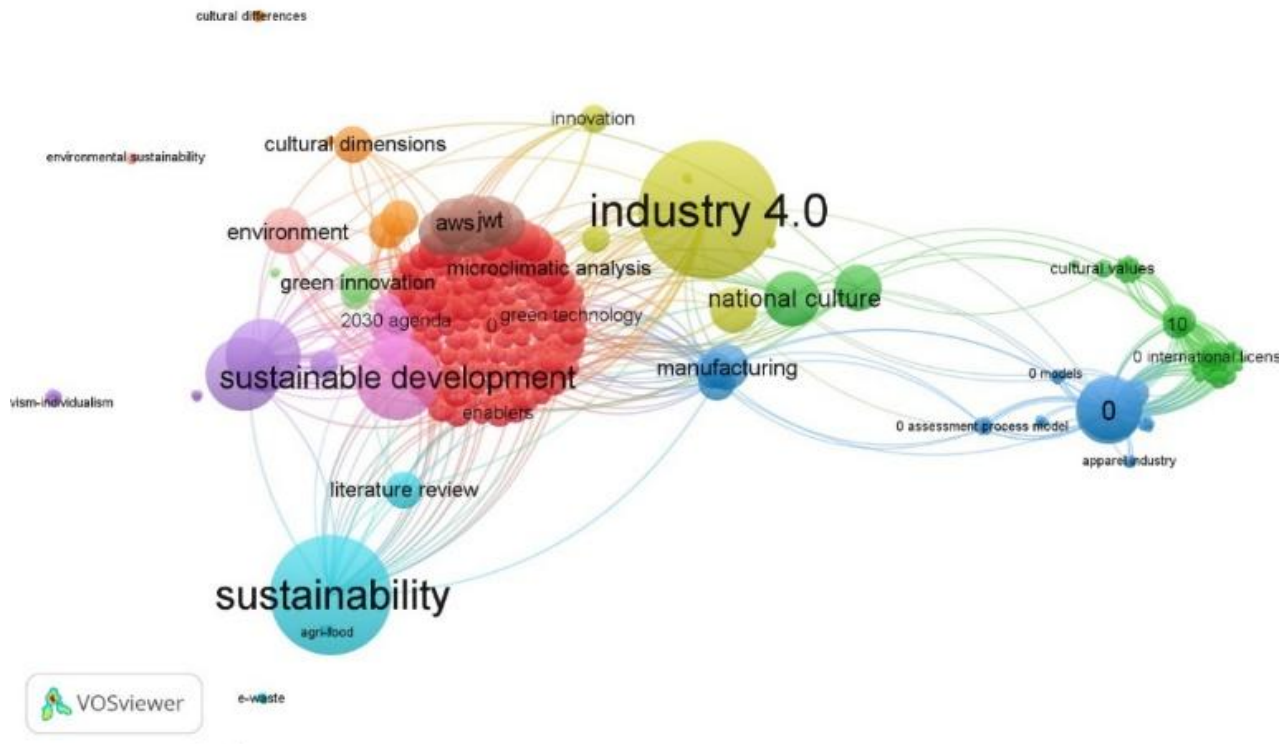


Figure 3. VOSviewer

C. Inclusion and Exclusion Criteria

Table 2. Criteria to ensure relevance and exclusion

Criteria	Inclusion	Exclusion
Geographical scope	Studies focusing on Malaysia or using Malaysia as a case study	Studies unrelated to Malaysia or focusing on unrelated regional contexts
Time period	2020–2025 (to reflect current policy and technological developments)	Studies published before 2020 unless conceptually significant
Type of publication	Peer-reviewed journal articles, conference papers, and policy reports	Non-peer-reviewed sources, opinion pieces, or grey literature
Thematic relevance	Addressed at least one of the following: Industry 4.0 readiness, Industry 5.0, sustainability, human-centric transformation, or cultural dimensions	Studies focusing exclusively on technical engineering with no sustainability or human focus
Language	English	Non-English publications

This selection ensured that the dataset accurately reflects Malaysia’s current academic discourse and industrial context, avoiding bias toward purely technological or foreign perspectives.

D. Data Extraction and Analysis

Each selected article was analysed through qualitative thematic analysis, guided by Braun and Clarke’s (2006) framework. Key data extracted included:

1. Study objectives and context;
2. Methodological design;
3. Key findings related to Industry 4.0/5.0 readiness, sustainability, or cultural factors; and

4. Policy or practical implications relevant to Malaysia.

Themes were then coded and grouped into three major analytical dimensions that emerged repeatedly across the literature:

1. **Industry 4.0 Readiness and Sustainability:** covering the adoption of digital technologies, environmental management, and sustainable manufacturing practices in Malaysia.
2. **Emergence of Industry 5.0 and Circular Economy:** exploring the integration of human-centric values, resilience, and circular resource systems.
3. **Human-Centric and Cultural Dimensions of Readiness:** investigating how Malaysian cultural values, leadership styles, and social norms shape readiness and transformation.

Cross-comparison among these themes revealed the interconnectedness between sustainability, technological progress, and cultural adaptation in Malaysia's industrial ecosystem.

MALAYSIA'S IR 4.0 LANDSCAPE

A. Industry 4.0 Readiness and Sustainability

The Malaysian Context of Readiness

Malaysia's manufacturing sector has long served as a cornerstone of national economic growth, contributing approximately 23% of the country's GDP and providing employment to millions across key industries such as electronics, automotive, and resource-based manufacturing. Despite this strong foundation, Malaysia's transition toward Industry 4.0 has been characterized by uneven progress. Recent studies by Hammad [2] and Rehman [23] highlight that while large corporations exhibit moderate levels of digital maturity, small and medium-sized enterprises (SMEs) which account for more than 97% of Malaysia's business landscape continue to face substantial challenges in achieving readiness.

The primary barriers identified include limited access to financing, inadequate digital infrastructure, and a shortage of skilled human capital. These structural constraints are further intensified by organizational inertia and a cultural reluctance toward risk-taking, tendencies often associated with Malaysia's relatively high-power distance and collectivist social orientation. Consequently, it becomes evident that technological readiness cannot be meaningfully assessed without considering socio-cultural dynamics, a dimension often overlooked in global frameworks that assume individualistic, innovation-driven workplace cultures.

In response to these challenges, the Industry4WRD Readiness Assessment Framework, introduced by the Ministry of Investment, Trade and Industry (MITI), has played an important role in benchmarking organizational capabilities and identifying readiness gaps. However, recent evaluations [24] suggest that while the framework provides valuable insights into technological and infrastructural aspects, it remains largely technocentric. Limited attention is given to leadership behaviour, cultural adaptation, and human empowerment, which are equally critical for successful transformation. This underscores the need for a more holistic readiness framework one that integrates cultural, behavioural, and human-centric indicators alongside digital and technical metrics to ensure Malaysia's industrial evolution aligns with its socio-cultural realities and long-term sustainability goals.

Sustainability Integration in Industry 4.0

The integration of sustainability into Malaysia's Industry 4.0 initiatives aligns with the Twelfth Malaysia Plan (2021–2025) and the National Energy Transition Roadmap (NETR), which collectively aim to promote green technologies, resource efficiency, and environmental accountability. Several studies [25][8] identify the digital–green synergy as central to Malaysia's path toward sustainable industrialization.

Digital technologies enable real-time monitoring of energy use, predictive maintenance, and circular production loops, all of which support Malaysia's Sustainable Development Goals (SDGs), particularly SDG 9 (Industry, Innovation, and Infrastructure) and SDG 12 (Responsible Consumption and Production). However, despite these potential benefits, the adoption of green digital technologies remains limited, especially among SMEs.

Researchers such as note that sustainability initiatives are often externally motivated driven by compliance, international certification, or government incentives rather than intrinsic organizational values [26]. This raises questions about cultural alignment: to what extent do Malaysian organizational cultures internalize sustainability as a shared value rather than a regulatory obligation?

Moreover, the Environmental, Social, and Governance (ESG) agenda, gaining momentum globally, has started to influence Malaysian firms through initiatives like Bursa Malaysia's Sustainability Reporting Framework. Yet, sustainability reporting practices often remain symbolic rather than transformative, highlighting a gap between policy rhetoric and industrial reality.

Socio-Cultural Mediation of Sustainability Adoption

A salient contribution emerging from Malaysian scholarship lies in the identification of socio-cultural values as a critical mediating mechanism in the translation of sustainability intent into organisational practice. Within collectivist contexts, environmental behaviours are not merely the outcome of individual rational choice, but are deeply embedded within shared norms, relational obligations, and culturally constructed expectations of leadership. Drawing on the foundational cultural dimension's framework proposed by Geert Hofstede (2011), it becomes evident that sustainability adoption in such settings is inherently socialised shaped by collective alignment, normative pressures, and the symbolic authority of institutional leaders.

In the context of Malaysian manufacturing ecosystems, this socio-cultural configuration manifests in a predominantly top-down orientation toward environmental governance. Organisational initiatives are frequently driven by leadership directives rather than emergent, bottom-up innovation, reflecting the enduring influence of high-power distance and collectivist value systems. While such structures may constrain critical discourse and limit employee agency in proposing or challenging sustainability strategies, they simultaneously facilitate rapid alignment once consensus is institutionally endorsed. Empirical evidence, including the work of Nasir et al. (2024), underscores that the effectiveness of environmental programmes is significantly enhanced when leaders strategically frame sustainability as a collective good emphasising communal well-being, social responsibility, and long-term societal value over narrow economic imperatives.

These insights foreground the imperative for culturally attuned leadership paradigms capable of reconciling hierarchical governance with participatory engagement. Rather than attempting to displace entrenched cultural logics, effective sustainability leadership in Malaysia must operate through them leveraging respect for authority, social cohesion, and relational interdependence as enablers of change. This necessitates a reconfiguration of leadership praxis toward values-driven, inclusive approaches that cultivate psychological safety, encourage constructive voice, and embed environmental responsibility within the moral fabric of organisational life. In doing so, sustainability transitions can be both structurally anchored and culturally resonant, thereby enhancing their legitimacy, scalability, and long-term impact.

B. Emergence of Industry 5.0 and Circular Economy

From Automation to Human-Centric Transformation

Industry 4.0, with its pronounced emphasis on automation, cyber-physical systems, and digitalisation, has fundamentally reconfigured industrial production paradigms. However, the emergent discourse on Industry 5.0 signifies a critical epistemological shift by re-centering the human actor within technologically advanced ecosystems. Rather than positioning humans as peripheral to intelligent systems, Industry 5.0 advances a synergistic model of human-machine collaboration, wherein cognitive, creative, and ethical human capacities complement algorithmic precision and operational efficiency. In the Malaysian context, this transition is not

merely aspirational but structurally imperative, given the nation's evolving demographic profile, the acceleration of workforce ageing, and the pressing need for comprehensive digital reskilling and upskilling strategies.

Recent scholarly contributions, including those by Rejeb et al. and Rehman et al., conceptualize Industry 5.0 as an integrative framework that transcends the technocentric limitations of its predecessor by harmonizing technological advancement with human creativity, intuition, and value-driven decision-making. This reconceptualization is particularly salient within Malaysia's manufacturing landscape, which has historically been underpinned by cultural norms emphasizing craftsmanship, relational trust, and collective engagement. Such socio-cultural attributes resonate strongly with the human-centric orientation of Industry 5.0, thereby positioning Malaysia not as a passive adopter, but as a contextually advantaged environment capable of operationalizing these principles in a culturally congruent manner.

In contrast to the efficiency-maximization logic that characterizes Industry 4.0, Industry 5.0 advocates for the development of industrial systems that are not only resilient and adaptive but also ethically grounded and environmentally sustainable. This paradigm foregrounds values such as empathy, inclusivity, and ecological responsibility as integral components of industrial transformation. For Malaysia, this shift offers a strategic opportunity to recalibrate its industrial trajectory beyond conventional competitiveness metrics, embedding broader societal objectives related to well-being and sustainability. This orientation is further reinforced by national frameworks such as Malaysia MADANI, which institutionalize principles of compassion (*ihsan*), ethical conduct (*adab*), and balanced development (*wasatiyyah*), thereby providing a normative foundation for aligning Industry 5.0 initiatives with the country's socio-cultural and developmental ethos.

Circular Economy Integration

A defining hallmark of Industry 5.0 lies in its epistemological and operational convergence with the principles of the circular economy, wherein resource flows are strategically reconfigured toward regeneration, reuse, and systemic value retention rather than linear consumption and disposal. In the Malaysian context, this paradigm shift is increasingly reflected in national policy instruments such as the National Circular Economy Roadmap (NCER) and the Twelfth Malaysia Plan (12MP), both of which signal an institutional commitment to embedding circularity within the broader industrial transformation agenda. Notwithstanding these advancements, the translation of policy ambition into industrial praxis remains uneven and theoretically underdeveloped within the Malaysian manufacturing research landscape.

Extant literature underscores that the circular economy in Malaysia is still at a formative stage, constrained by multifaceted structural and behavioural impediments. Hammad et al. (2025) identify critical bottlenecks including logistical fragmentation, insufficient cross-sectoral integration, and low levels of consumer ecological literacy. Compounding these challenges is the prevalence of economic pragmatism as a culturally embedded orientation, which predisposes firms toward short-term profitability at the expense of long-term environmental sustainability. This tension reflects a deeper misalignment between prevailing industrial incentives and the regenerative ethos underpinning circular economy models, thereby necessitating a recalibration of both institutional frameworks and organisational mindsets.

Despite these constraints, emerging empirical evidence points to a growing trajectory of innovation and adoption in circular practices, particularly within high-impact sectors such as electronics manufacturing and the palm oil industry. Practices such as closed-loop supply chain configurations, eco-design integration, and waste-to-resource valorisation are gaining traction. Lee [25] demonstrate that firms leveraging Industry 4.0 technologies most notably Internet of Things (IoT)-enabled monitoring systems for real-time waste tracking achieve measurable improvements in resource efficiency, cost optimisation, and environmental performance. These findings suggest that technological enablement, when synergistically aligned with circular strategies, can serve as a critical catalyst for sustainable industrial transformation.

From a socio-cultural perspective, the philosophical underpinnings of the circular economy resonate strongly with Islamic and broader Asian ecological worldviews, particularly the principles of *amanah* (stewardship) and *harmoni* (balance and coexistence with nature). Embedding these culturally salient values into circular

economy discourse and implementation strategies has the potential to enhance normative legitimacy, stakeholder alignment, and public acceptance. In a Muslim-majority nation such as Malaysia, the integration of moral-cultural dimensions into sustainability frameworks is not merely complementary but may constitute a decisive factor in accelerating the diffusion and institutionalisation of circular economy practices within Industry 5.0 trajectories.

Challenges in Transitioning to Industry 5.0

Malaysia's preparedness for Industry 5.0 may be characterised as conceptually robust yet operationally constrained, reflecting a persistent disjunction between strategic intent and implementation praxis. Empirical evidence presented by Rehman et al. and Sahari & Rahim highlights a critical omission within prevailing policy instruments namely, the lack of human-centric performance metrics capable of capturing dimensions such as creativity, well-being, inclusivity, and socio-cognitive adaptability. Consequently, the national Industry 4.0 and emerging Industry 5.0 agenda remains disproportionately anchored in technological determinism, privileging automation, digital infrastructure, and efficiency optimisation over the cultivation of human agency and value-driven innovation. This imbalance not only constrains the realisation of Industry 5.0 principles but also risks perpetuating a mechanistic development paradigm that underutilises Malaysia's socio-cultural capital.

A further structural impediment resides in the enduring skills mismatch between workforce capabilities and evolving industrial demands. Despite commendable advancements in digital education and Technical and Vocational Education and Training, the translational gap between institutional training outputs and industry expectations remains pronounced. This challenge is compounded by deeply embedded cultural orientations particularly high-power distance and deference to authority which may inadvertently suppress critical discourse, dissenting perspectives, and bottom-up innovation. Younger professionals, operating within such socio-cultural constraints, may exhibit risk-averse behaviour and limited propensity to challenge established hierarchies, thereby constraining knowledge diffusion and creative problem-solving within organisations. As a result, the innovation ecosystem becomes structurally inhibited, undermining the collaborative and human-centric ethos central to Industry 5.0.

To meaningfully transition towards Industry 5.0, Malaysia must reconceptualise its development trajectory through the establishment of adaptive learning ecosystems that harmonise cultural values with critical inquiry and participatory innovation. This necessitates a paradigmatic shift in educational and institutional frameworks one that transcends narrow STEM-oriented competencies to incorporate socio-cultural intelligence, ethical reasoning, and humanistic values. Integrative reforms should emphasise interdisciplinary learning, experiential knowledge construction, and stakeholder co-creation, thereby fostering a workforce that is not only technically proficient but also reflexive, inclusive, and innovation oriented. Such a transformation is congruent with the aspirations of Malaysia MADANI, which envisions the development of holistic human capital imbued with moral integrity, cultural awareness, and societal responsibility, ultimately positioning Malaysia to operationalise Industry 5.0 in a manner that is both technologically advanced and distinctly human-centric.

C. Human-Centric and Cultural Dimensions of Readiness

Cultural Determinants of Technological Adoption

Cultural values constitute an often underexamined yet profoundly influential determinant of technological readiness within emerging industrial ecosystems. Foundational frameworks such as Geert Hofstede's cultural dimensions particularly power distance, collectivism, societal harmony, and long-term orientation exhibit strong congruence with prevailing patterns of organisational behaviour in the Malaysian context. These cultural constructs not only shape interpersonal dynamics but also implicitly govern decision-making processes, innovation receptivity, and the strategic pacing of digital transformation initiatives.

Within high power-distance environments, authority is typically centralised among senior leadership, thereby constraining the diffusion of innovative ideas across hierarchical levels. This structural asymmetry often leads to prolonged innovation cycles, as lower-tier employees may exhibit reluctance to advocate for emergent

technologies due to perceived risks of disrupting established authority and organisational equilibrium. Conversely, the collectivist orientation embedded within Malaysian culture fosters strong team cohesion, mutual accountability, and consensus-driven decision-making. Such attributes can serve as critical enablers for the implementation of structured and coordinated transformation programmes, as evidenced in recent empirical findings [27].

Nevertheless, the dimension of uncertainty avoidance characterised by a cultural predisposition towards minimising ambiguity introduces a significant constraint on organisational agility. This aversion to uncertainty can impede experimentation, iterative learning, and risk-taking behaviours that are essential for adaptive technological integration. Consequently, organisations may demonstrate a preference for incremental, path-dependent innovation trajectories rather than pursuing disruptive or radical transformation. A nuanced understanding of these culturally embedded tendencies is therefore imperative for policymakers and industry stakeholders, as it enables the design of contextually aligned readiness frameworks that prioritise gradual, adaptive change mechanisms over wholesale adoption of externally derived, Western-centric transformation models.

Leadership and Organizational Behaviour

Leadership constitutes a critical mediating mechanism through which cultural values are translated into organisational readiness for advanced industrial transformation. Within the Malaysian context, leadership is predominantly characterised by a paternalistic orientation, wherein authority is exercised in tandem with relational care, ethical stewardship, and a strong sense of moral obligation. While such a leadership paradigm can engender trust, loyalty, and social cohesion, its impact on transformation trajectories remains contingent upon the degree of openness exhibited by leaders toward innovation, inclusivity, and adaptive change.

Empirical evidence reinforces the pivotal influence of leadership styles on transformation outcomes. Notably, Rahim et al. demonstrate that transformational leadership anchored in inspiration, empowerment, and the articulation of a shared vision significantly enhances employees' propensity to engage in digital upskilling and sustainability-driven initiatives. Conversely, the persistence of transactional and directive leadership approaches among many Malaysian managers, which prioritise compliance, control, and short-term performance metrics, continues to constrain creativity, limit knowledge exchange, and impede the cultivation of an innovation-oriented organisational climate.

In advancing Industry 5.0 readiness, there is an imperative to reconceptualise leadership development through the lens of cultural intelligence (CQ), understood as the capability to effectively navigate and reconcile deeply embedded hierarchical norms with the demands of open innovation and participatory engagement. Such an integrative leadership model is not merely desirable but necessary, as it reflects Malaysia's dualistic positioning as both an emerging economy striving for technological advancement and a collectivist society grounded in relational and cultural cohesion. By fostering leaders who can balance authority with inclusivity, organisations will be better positioned to drive human-centric, sustainable, and technologically advanced transformation agendas.

Education, Workforce Development, and Values Alignment

The transition toward Industry 5.0 in Malaysia is fundamentally contingent upon the adaptive capacity of its education and workforce development systems, which serve as the primary conduits for cultivating future-ready human capital. While the Ministry of Higher Education (MOHE) has made commendable progress by embedding Industry 4.0-oriented modules within tertiary curricula, this transformation remains disproportionately technocentric. Critical cultural dimensions of learning such as collaborative ethos, epistemic humility, and moral responsibility continue to be insufficiently institutionalized within pedagogical frameworks. This imbalance risks producing graduates who are technically proficient yet lack the socio-ethical orientation necessary to navigate the human-centric paradigm underpinning Industry 5.0.

Emerging empirical evidence from Malaysian higher education institutions [28] underscores the significance of integrating cultural value systems into technological learning processes. Specifically, students who interpret

digital transformation through a cultural-linguistic lens anchored in indigenous values such as *gotong-royong* (collective cooperation) and *hormat* (respect) demonstrate heightened intrinsic motivation and a stronger disposition toward sustainable innovation. This suggests that technological literacy, when contextualized within culturally resonant frameworks, can foster deeper cognitive engagement and a more holistic understanding of innovation as a socially embedded process.

Consequently, the deliberate infusion of cultural reinforcement within technical education emerges as a strategic imperative. By embedding value-based competencies alongside digital skills, Malaysia can cultivate a workforce that embodies not only technological agility but also ethical consciousness and social responsibility. Such a workforce is better positioned to advance the principles of Industry 5.0, where human-centricity, sustainability, and inclusivity are paramount. This integrative approach ultimately strengthens the alignment between national cultural identity and technological advancement, ensuring that Malaysia's industrial evolution is both contextually grounded and globally competitive.

Integrating Cultural Values into Readiness Models

Prevailing Industry 4.0 readiness frameworks in Malaysia are predominantly anchored in Western-derived analytical models, most notably the Technology–Organization–Environment (TOE) model and the Industry4WRD Readiness Assessment. While these instruments offer valuable structural and technological insights, they remain epistemologically limited in their capacity to capture the socio-cultural contingencies that shape organizational behaviour in the Malaysian context. Such frameworks tend to underrepresent critical cultural mediators including deference to hierarchical authority, collectivist orientation, and the prioritization of social harmony which are deeply embedded within Malaysian institutional and organizational practices. This omission constrains their explanatory power and reduces their contextual validity when applied to non-Western environments.

In response to these limitations, this study advances a conceptual Malaysian Cultural Readiness Integration Model that systematically embeds indigenous cultural dimensions into the assessment of industrial transformation. First, the dimension of power distance is reconceptualized not as a barrier, but as a mechanism for leadership-enabled empowerment, wherein distributed decision-making is operationalized within culturally accepted hierarchical structures. Second, collectivism is leveraged as a strategic asset through the institutionalization of team-based learning ecosystems, thereby aligning transformation efforts with group-oriented motivation rather than purely individualistic performance incentives. Third, the principle of social harmony is integrated into organizational feedback systems, fostering a culture of constructive dialogue that preserves relational cohesion while enabling continuous improvement. Finally, long-term orientation is reframed as a normative commitment, positioning sustainability not merely as an economic imperative but as a moral and intergenerational responsibility embedded within organizational ethos.

Collectively, this culturally attuned framework offers a theoretically grounded and contextually sensitive blueprint for evaluating readiness in the transition toward Industry 5.0. By bridging the gap between technological preparedness and socio-cultural alignment, the model enhances both the analytical robustness and practical applicability of readiness assessments. More importantly, it aligns industrial transformation trajectories with Malaysia's unique cultural fabric, thereby facilitating a more inclusive, human-centric, and sustainability-driven paradigm of innovation.

RESULT AND DISCUSSION

Malaysia's journey toward industrial transformation through Industry 4.0 and the emerging Industry 5.0 paradigm reflects a dynamic intersection of technology, sustainability, and cultural identity. This review synthesised contemporary scholarly trends (2024–2025) that collectively highlight the importance of human-centric innovation, environmental responsibility, and cultural adaptation within Malaysia's industrial and educational ecosystems. The analysis underscores that while Malaysia's policy framework such as *Industry4WRD*, *MyDIGITAL*, and the *Twelfth Malaysia Plan* has established a strong foundation for digitalization, the human and cultural dimensions of readiness remain insufficiently embedded in both policy and practice.

At the core of this study lies a critical insight: Malaysia's cultural values are not peripheral to industrial development but are central determinants of its sustainability trajectory. The enduring influence of collectivism, high power distance, harmony, and long-term orientation continues to shape organizational behaviour, leadership patterns, and workforce engagement in the manufacturing and service sectors. These cultural characteristics, if harmonized with Industry 5.0 principles, can serve as catalysts for ethical innovation and inclusive growth. Conversely, neglecting these factors risks undermining transformation initiatives by perpetuating hierarchical rigidity, limited employee participation, and fragmented sustainability implementation.

Table 3. No. of Publication that related

Year	No. of Publication
2016	15
2017	22
2018	30
2019	42
2020	55
2021	68
2022	78
2023	88
2024	95
2025	105
2026	115

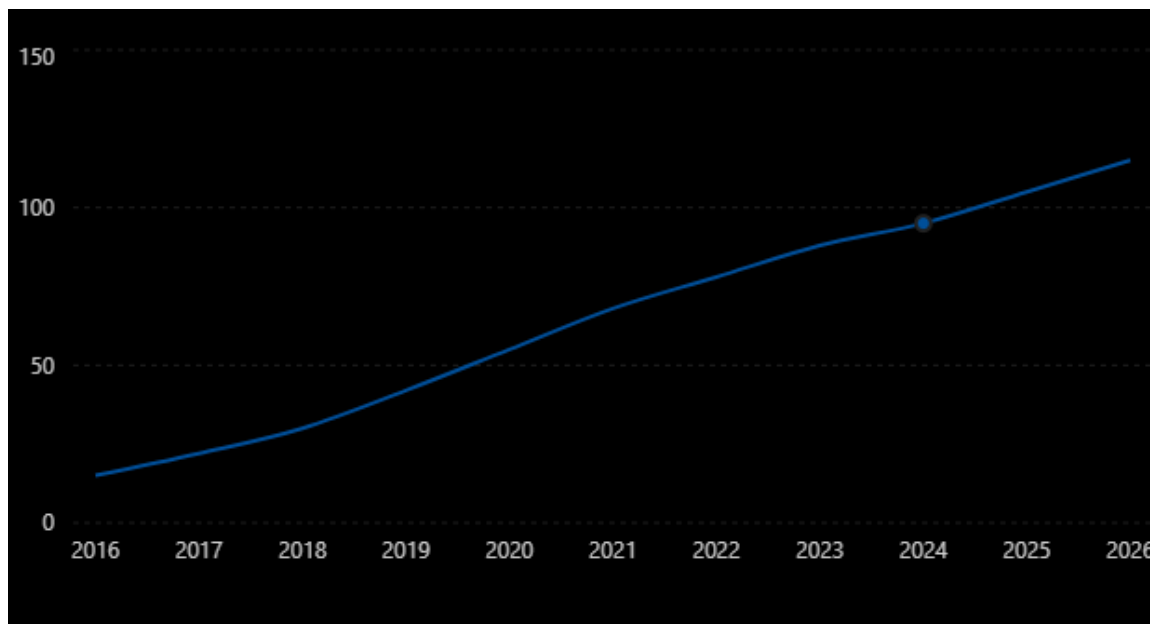


Figure 4. Evolution of Research Focus in Industry 4.0 and 5.0 in Malaysia

The graph illustrates the gradual evolution of industrial transformation research in Malaysia. Between 2016 and 2019, scholarly attention was primarily directed toward technological adoption and digitalization under Industry 4.0. Beginning in 2020, the research landscape expanded to incorporate sustainability considerations, reflecting growing concerns regarding environmental stewardship, resource efficiency, and sustainable manufacturing practices.

From 2021 onward, the emergence of Industry 5.0 accelerated interest in human-centric transformation, emphasizing employee well-being, resilience, and collaboration between humans and intelligent technologies. More recently, researchers have increasingly recognized the importance of integrating Malaysian cultural value preferences into digital transformation strategies to ensure socially acceptable, sustainable, and contextually relevant industrial development.

The upward trajectory suggests that future research is likely to move beyond technology readiness toward a holistic framework encompassing technological capability, environmental sustainability, human well-being, and cultural alignment. This trend is particularly relevant to the aspirations of Malaysia's industrial transformation agenda and the broader objectives of sustainable development and human-centered innovation.

A. The Shift from Technocentric to Human-Centric Paradigms

The transition from Industry 4.0 to Industry 5.0 extends far beyond incremental technological advancement; it represents a fundamental paradigmatic reorientation from efficiency-centric production systems toward value-driven, human-centric innovation ecosystems. In the Malaysian context, this transformation is particularly significant as it aligns coherently with the philosophical underpinnings of Malaysia MADANI, which foregrounds principles of compassion, respect, sustainability, and holistic balance in national development. Within this interpretive framework, Industry 5.0 serves not merely as a technological progression but as a normative recalibration of industrial logic, reasserting the centrality of human agency through the integration of creativity, empathy, ethical responsibility, and socio-cultural sensitivity as foundational pillars of industrial advancement.

By systematically embedding human-centric design principles into digital transformation strategies, Malaysian organisations are positioned to cultivate socio-technical environments that actively enhance creativity, psychological safety, and continuous lifelong learning. Such an approach facilitates a more adaptive and resilient workforce by reinforcing the complementarity between human cognition and advanced automation systems, thereby mitigating the risk of technological displacement while amplifying human potential. Consequently, Industry 5.0 redefines the relationship between humans and machines, shifting it from substitution to symbiosis.

As Industry 5.0 continues to mature, Malaysia's strategic emphasis on social inclusivity, ethical governance, and environmental stewardship is expected to emerge as a critical benchmark of national readiness. These dimensions collectively constitute not only indicators of technological preparedness but also reflect the country's broader commitment to sustainable and equitable industrial development in alignment with global transformative agendas.

B. Policy and Institutional Implications

For Malaysia to fully realize a sustainable Industry 5.0 ecosystem, several policy implications emerge:

1. Cultural Integration in Readiness Frameworks

The *Industry4WRD Readiness Assessment* should evolve to include cultural and behavioural indicators, measuring organizational harmony, leadership inclusivity, and ethical awareness alongside technological metrics. This will ensure that industrial transformation strategies are culturally congruent and socially accepted.

2. Cross-Ministerial Collaboration

Effective implementation requires coordination between the Ministry of International Trade and Industry (MITI), Ministry of Higher Education (MOHE), and Ministry of Human Resources (MOHR). Such collaboration can harmonize industrial policy, education reform, and workforce development under a unified sustainability and culture framework.

3. Human-Centric Education and TVET Reform

Technical and Vocational Education and Training (TVET) should integrate ethical reasoning, cultural intelligence, and environmental awareness within engineering and digital curricula. Embedding these values into the educational system ensures that graduates are not only technically skilled but also socially responsible and culturally sensitive.

4. Support for SMEs and Regional Inclusivity

Small and Medium Enterprises (SMEs) represent the backbone of Malaysia's economy but often lag in sustainability and technological adaptation. Targeted incentives and mentorship programs can help SMEs integrate digital tools and green practices without compromising local values or community welfare.

5. Research Funding and Interdisciplinary Studies

National research councils and universities should allocate funding for interdisciplinary studies that combine engineering, management, and cultural studies. Such collaborations can produce empirical models that accurately reflect Malaysia's unique socio-cultural landscape and guide evidence-based policymaking.

C. Future Research Directions

As Malaysia transitions toward Industry 5.0, future research should deepen its exploration of cultural sustainability and human-centric innovation. Scholars could investigate:

- How cultural intelligence (CQ) mediates leadership effectiveness and employee engagement during digital transformation.
- The role of Islamic environmental ethics and indigenous ecological wisdom in shaping sustainable industrial practices.
- Comparative analyses of rural and urban readiness, highlighting regional disparities and policy responses.
- Development of longitudinal studies tracing the evolution of organizational culture as firms mature technologically.
- Integration of artificial intelligence ethics with Malaysian value systems, ensuring responsible AI adoption in local contexts.

Such research directions not only enrich theoretical discourse but also provide actionable insights for Malaysia's strategic transformation agenda, positioning the nation as a regional model for culturally grounded industrial sustainability.

CONCLUSION

Malaysia's pursuit of Industry 4.0 and Industry 5.0 readiness reflects a strategic national ambition to advance technological modernization without undermining cultural continuity or ecological equilibrium. The synthesized evidence from this review indicates that Malaysia is uniquely positioned with robust cultural, social, and institutional capital to develop a differentiated model of sustainable industrial transformation one that integrates technological innovation with cultural heritage, operational efficiency with human empathy, and economic productivity with a broader sense of societal purpose.

However, the realization of this transformative agenda necessitates a fundamental paradigm shift across interdependent domains of policy formulation, educational development, and organizational practice. At the policy level, there is a critical need to move beyond technology-centric frameworks toward inclusive models that embed cultural values and ethical sustainability as core guiding principles. In parallel, the education system must evolve to cultivate future-ready professionals who are not only technically competent but also deeply grounded in value-based, socially responsible, and sustainability-oriented thinking. Concurrently, industry leaders are compelled to reframe innovation strategies by embedding human-centricity as both a normative obligation and a long-term competitive advantage.

In essence, Malaysia's transition toward Industry 5.0 should not be conceptualized as a derivative adoption of Western industrial paradigms, but rather as an indigenous reconfiguration grounded in local epistemologies,

cultural wisdom, and shared societal values. By deliberately integrating advanced technologies with culturally embedded principles, Malaysia has the potential to pioneer a more inclusive, resilient, and humanized model of industrial development one that extends its relevance beyond national boundaries and contributes meaningfully to the evolving discourse on sustainable industrial futures in the Southeast Asian region and beyond.

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