Industry 5.0 as a Pathway for Syria's Economic and Social Reconstruction: A Human-Centered Conceptual Framework for Sustainable Development

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ABSTRACT

Post-conflict reconstruction presents complex challenges that extend beyond physical rebuilding to encompass economic revitalization, social cohesion, institutional recovery, and environmental sustainability. Traditional reconstruction and industrial development models often prioritize efficiency-driven growth and large-scale technological adoption, approaches that risk deepening inequality and social exclusion in fragile contexts. In response, this study conceptualizes Industry 5.0 as a human-centered pathway for Syria's economic and social reconstruction, rather than as a technologically advanced endpoint of industrial evolution. Building on recent Industry 5.0 scholarship and sustainability transition literature, the paper develops an integrative conceptual framework that aligns human-centric, sustainable, and resilient principles with enabling socio-technical and institutional mechanisms, and reconstruction-oriented outcomes. The framework is explicitly designed for post-conflict contexts, where labor-intensive recovery, SME revitalization, skills regeneration, and trust-building are critical priorities. Through a critical engagement with existing Industry 5.0 models, the study demonstrates that prevailing frameworks remain insufficiently contextualized for fragile and conflict-affected economies. The proposed framework advances theory by reframing Industry 5.0 as a development philosophy capable of supporting incremental, inclusive, and socially embedded reconstruction. By placing Syria at the center of analysis, the study contributes to emerging debates on Industry 5.0, sustainability transitions, and post-conflict development, offering a foundation for future empirical research and policy experimentation in similarly fragile environments.

Keywords: Industry 5.0; post-conflict reconstruction; Syria; human-centered development; sustainability transitions; conceptual framework

1. Introduction

Post-conflict reconstruction presents multidimensional challenges that extend beyond physical infrastructure to encompass economic recovery, institutional rebuilding, social cohesion, and environmental sustainability. Syria, has been undergoing over a decade of conflict, exemplifies such a context, where decades of industrial disruption, labor displacement, and institutional fragility have severely constrained conventional development pathways (Dalati 2021, 2023, Dalati et al, UNDP, 2023). Traditional reconstruction models often prioritize rapid economic growth through large-scale industrialization or technological adoption, yet these approaches risk exacerbating unemployment, inequality, and social exclusion if they neglect the human, social, and ethical dimensions of development. In fragile environments, there is a pressing need for integrated frameworks that simultaneously address technological advancement, human development, and sustainable reconstruction. Industry 5.0, emerging as a conceptual evolution

from Industry 4.0, offers a potentially transformative paradigm in this regard. Unlike its predecessor, which emphasizes automation, efficiency, and data-driven industrial optimization, Industry 5.0 foregrounds human-centricity, sustainability, and resilience (Alves et al., 2023; Leng et al., 2022; Xu et al., 2023). It envisions a collaborative interface between humans and machines, ethical governance, and socially inclusive innovation, positioning technology as a tool for human empowerment rather than mere productivity enhancement. Despite increasing scholarly attention, current Industry 5.0 models remain largely grounded in stable industrial contexts, with limited consideration of their applicability to fragile, post-conflict economies.

This study seeks to address this gap by conceptualizing Industry 5.0 as a reconstruction-oriented development philosophy for Syria. Specifically, it proposes an integrative conceptual framework that aligns the normative principles of Industry 5.0—human-centricity, sustainability, and resilience—with enabling mechanisms, including institutions, technology and skills, economic actors, and governance systems, to produce tangible reconstruction outcomes: economic revitalization, social cohesion, and environmentally responsible growth. By situating Syria at the center of analysis, the study foregrounds the practical relevance of the framework for contexts where post-conflict dynamics—such as labor-intensive recovery, SMEs revitalization, and trust rebuilding—are paramount.

The research contributes to the emerging literature on Industry 5.0 in several ways. First, it extends existing conceptual models by embedding them within post-conflict reconstruction logic, thereby bridging industrial and societal transformation discourses. Second, it provides a systems-oriented and layered analytical structure that clarifies the relationships among normative principles, operational mechanisms, and reconstruction outcomes. Third, the framework offers a foundation for future empirical testing, policy experimentation, and sectoral adaptation in Syria and other fragile contexts, advancing both theoretical understanding and practical applicability.

The study posits that Industry 5.0, when reinterpreted as a human-centered, sustainable, and context-sensitive paradigm, can offer a meaningful pathway for Syria's economic and social reconstruction. By providing a coherent conceptual framework, the research seeks to inform scholars, policymakers, and development practitioners on the integration of industrial innovation with post-conflict development imperatives.

This study extends Industry 5.0 theory beyond advanced industrial contexts by reconceptualizing it as a human-centered reconstruction framework for post-conflict economies. This study makes three key theoretical contributions. First, it extends Industry 5.0 theory beyond advanced industrial economies by reconceptualizing it as a human-centered reconstruction framework applicable to post-conflict contexts. Second, it integrates Industry 5.0 principles with post-conflict reconstruction and sustainable development literatures, offering a novel interdisciplinary lens that links technological innovation with social cohesion, institutional rebuilding, and environmental sustainability. Third, the study advances conceptual understanding by positioning Industry 5.0 not as a technological stage, but as a normative development paradigm capable of guiding inclusive and resilient economic and social reconstruction in fragile environments such as Syria.

2. Evolution of Industry Revolutions: From First to Fifth

The first industrial revolution began in the second half of the 18th century 1760s, powered by the invention of the steam engine, bringing significant improvement in mechanization, transportation, by the use of steam ships and steam locomotives, urbanization with transformation from urban regions to work in factories. This era was characterized by introduction of new manufacturing processes, creation of factories and textiles industry.

The Second industrial revolution began in the late 19th century (1870) which was characterized by new ways to use energy, internal combustion engines, and electricity and light bulb. This resulted in easier communication in the form of telephones and telegraphs. Most importantly the 2nd industrial revolution prepared for the introduction of mass production and model of T mass production in 1913, steel industry.

The third Industrial revolution (Digital Revolution) began in the second half of the 20th century The introduction of computerization, semiconductors, personal computer and internet.

The fourth industrial revolution (Industry 4.0) is characterized by advanced and vast technology as Nano technology, 3D printing with practical application in medical industry, and AI applications. Industry 4.0 is characterized by smart factories and machines connected to networks, big data that can be used to solve problems in real time, powered by AI which can be used to make sense of this data, as predictive maintenance, which helps businesses to predict and fix problems before they happen. The application of industry 4.0 is functional in interconnected supply chain, where transportation means are inter-connected to warehouses, where intelligent robots can be functional and useful.

The fifth industrial revolution (industry 5.0) is characterized by critical transformation of industry development going beyond limitations (Calzavara et al 2023). Industry 5.0 focuses its attention on sustainability, social wellbeing and collaborations between humans and robots. The emphasis of industry 5.0 is on mitigating environmental impacts and caring for the welfare of human and social entities. Industry 5.0 introduces a societal agenda, aiming to regulate the digital industrial transformation in a way that aligns with sustainability goals (Destouet et al., 2023). Figure 1 illustrates the industry evolution from first to Fifth.

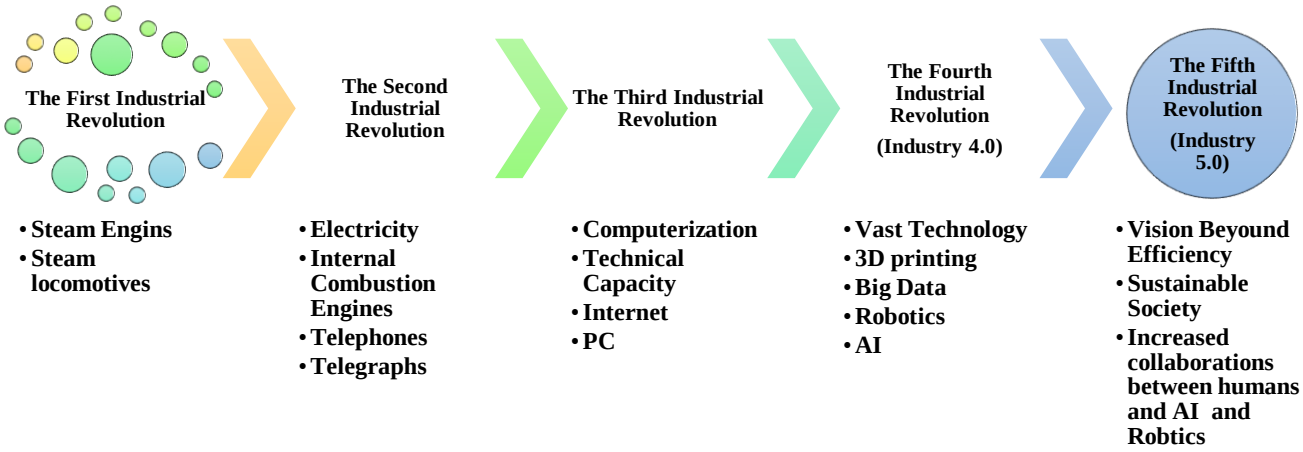

Figure 1. Evolution of Industry from first Industry Revolution to industry 5.0

It is critical to differentiate between industry 4.0 and 5.0 Industry 5.0 is characterized by the emphasis on technology enhancement and the application of AI, compared with industry 5.0 which focuses on social sustainability and human wellbeing (Youssef and Mejri 2023, Dalati 2021). Industry 5.0 places further emphasis and significance of sustainable organizational and business practices including concern for ecological boundaries, individual and social welfare of human resources (Battini et al 2022).

Syrian context during and post conflict era. Syria is located in the Middle East, bordered by countries such as Turkey, Lebanon, Jordan, and Iraq. The culture is heavily influenced by patriarchal and tribal Arabic traditions. There exist significant challenges faced by Syria's social, economic, legal and political environment in the aftermath of the Syrian uprising against Assad regime, began in 2011, which escalated

into civil war. After the Syrian uprising, the war has led to a dramatic decline in the Syrian infrastructure. This period of conflict has had severe consequences on various levels—social, economic, environmental, and political—resulting in massive displacement, loss of lives, jobs, and properties. Many individuals and families have left Syria to seek safer conditions abroad.

This research highlights the devastating effects of the turbulent political situation in Syria, which has lasted for nearly a decade. The Syrian population, once around 22.1 million in 2010, has since decreased by at least 20% by 2016, with over 250,000 fatalities due to the brutal Assad regime in defying the Syrian uprising ongoing conflict. These challenges suggest a pressing need for reforms to modernize Syria by empowering women, building cohesive civic peace and social unity, investing in youth, enhancing diversity and inclusion.

The need for robust management in Syria is increasingly growing in dimensions of the environment, which is becoming transnational, global, virtual, and boundary-less. The prevalent organizational settings in Syria could be strongly associated with corrupt and bureaucratic approaches, which enforce traditional and Micaville styles of management. The predominant styles of management overlook contemporary sustainable management approaches, which would tend to emphasize teambuilding, people empowerment, collaboration and emphasis on outstanding performance. There is requirement for contemporary management and leadership styles, which could sustain time, place, geography, and the environment becomes evident. The new reality of higher education sectors in Syria requires a robust and agile approaches in management which enforces empowerment over control, collaboration over competition, diversity over uniformity, and horizontal management structures over vertical management structures. Figure xxx illustrates the requirement of the new reality of higher education sectors in Syria.

Why Industry 5.0 in a Syrian post-conflict context? Post-conflict contexts are commonly characterized by institutional fragility, disrupted economic structures, erosion of human capital, and persistent social fragmentation (Collier et al., 2003; UNDP, 2022). Reconstruction strategies in such environments have often emphasized rapid economic recovery through large-scale industrialization or technology-led growth. While these approaches may generate short-term gains, they frequently overlook social inclusion, ethical governance, and environmental sustainability, thereby risking the reproduction of inequality and social exclusion in fragile societies (World Bank, 2018).

Within this context, Industry 5.0 offers a fundamentally different development paradigm. Rather than representing a technologically advanced successor to Industry 4.0, Industry 5.0 reorients industrial and economic development around human well-being, sustainability, and societal value creation (European Commission, 2021). Central to this paradigm are human–machine collaboration, inclusive innovation, and responsible governance, which position technology as a complement to human capabilities rather than a substitute for labor (Breque et al., 2021).

For post-conflict Syria, the relevance of Industry 5.0 lies in its adaptability to reconstruction realities. Syria's recovery requires employment-intensive growth, revitalization of small and medium-sized enterprises, rebuilding of skills and institutional trust, and environmentally responsible economic activity. Automation-centric industrial models associated with Industry 4.0 may be ill-suited to such conditions, as they presuppose advanced infrastructure and risk marginalizing vulnerable segments of the workforce. In contrast, a human-centered Industry 5.0 approach supports incremental reconstruction, local production systems, reskilling, and community-based economic initiatives, aligning technological development with social recovery objectives.

Accordingly, this study conceptualizes Industry 5.0 not as a high-technology endpoint, but as a normative and strategic framework for post-conflict reconstruction. By prioritizing human dignity, social cohesion, and sustainability, Industry 5.0 provides a pathway through which economic and social reconstruction can be pursued simultaneously, addressing both material rebuilding and the restoration of trust in fragile

contexts such as Syria. Table 1 illustrates why and how Industry 5.0 would be suitable for a Syrian Post-Conflict Context.

Table 1: Industry 5.0 in a Syrian Post-Conflict Context (developed by researcher)

Syria's Existing Reality	Industry 5.0 Response
High unemployment Rates	Human-centered job creation
Destroyed Infrastructure for large industries	SME- and community-based production
Deficiency in Skills & brain drain	Reskilling, lifelong learning
Social fragmentation	Collaborative, participatory models
Environmental damage	Circular economy & sustainability
Weak trust in institutions	Ethical governance & inclusivity

While Industry 5.0 is often associated with advanced technological systems, this study adopts a human-centered interpretation of Industry 5.0 that emphasizes social inclusion, sustainability, and ethical development rather than technological sophistication. In post-conflict contexts such as Syria, Industry 5.0 is conceptualized as a flexible and adaptive framework that supports incremental reconstruction, local production, and human capacity development.

3. Research Methodological Design

This study adopts a conceptual and analytical research design aimed at developing a human-centered framework that situates Industry 5.0 as a pathway for economic and social reconstruction in post-conflict contexts, with Syria serving as an illustrative case. Conceptual research is particularly appropriate when addressing phenomena that are emergent, under-theorized, and characterized by fragmented empirical evidence, where theory integration and clarification constitute the primary scholarly need (Jaakkola, 2020; Gilson & Goldberg, 2015). Industry 5.0 meets these conditions, as its academic consolidation has only recently occurred, and its application beyond advanced industrial economies remains insufficiently explored (Alves et al., 2023; Xu et al., 2023). Rather than pursuing hypothesis testing or empirical measurement, the objective of this study is to advance theoretical understanding by synthesizing recent Industry 5.0 scholarship with post-conflict reconstruction literature. This approach responds to recent calls for analytical frameworks capable of linking technological transformation with broader societal and institutional dynamics, particularly in contexts marked by fragility and structural disruption (Leadership Perspectives on Industry 5.0, 2024). Within the scope of Technological Forecasting & Social Change, such conceptual contributions are well established as a means of shaping future research agendas and informing policy debates.

Framework development procedure. The conceptual framework was developed through a structured and iterative synthesis of recent peer-reviewed literature, following established principles for theory-building and conceptual article design (Jaakkola, 2020). The procedure consisted of three analytically distinct, yet interrelated, stages. First, a focused review of Industry 5.0 literature published between 2022 and 2025 was conducted. This period reflects the phase in which Industry 5.0 moved from a policy concept to a subject of systematic academic inquiry. The review prioritized conceptual papers, systematic literature reviews, and policy-oriented studies that explicitly addressed the three core dimensions of Industry 5.0: human-centricity, sustainability, and resilience (Alves et al., 2023; Leng et al., 2022; Xu et al., 2023). This ensured that the framework was grounded in contemporary interpretations of Industry 5.0 rather than inferred from earlier

Industry 4.0 paradigms. Second, insights from the Industry 5.0 literature were analytically integrated with research on post-conflict reconstruction, economic recovery, and institutional rebuilding. Post-conflict development studies consistently emphasize that economic reconstruction cannot be decoupled from employment creation, skills regeneration, social cohesion, and institutional legitimacy (OECD, 2022; UNDP, 2023). Through comparative analytical mapping, this study identified conceptual complementarities between human-centered industrial models and post-conflict reconstruction priorities. This step enabled the reinterpretation of Industry 5.0 as a development-oriented framework, rather than a technologically deterministic model. Third, an abstraction and synthesis process was applied to organize the identified concepts into a coherent framework. Core elements were clustered into three interdependent layers—foundational principles, enabling systems and actors, and reconstruction outcomes. Layered conceptualization is commonly used in policy-oriented and systems-based research to capture the interaction between normative orientations, operational mechanisms, and societal impacts (Martini et al., 2024; Müller, 2025). This structure facilitates analytical clarity while preserving the complexity inherent in post-conflict reconstruction processes.

Analytical logic. The analytical logic underpinning the framework is systems-oriented and non-linear, reflecting the complex and adaptive nature of post-conflict reconstruction. Rather than assuming direct causality between technological adoption and development outcomes, the framework conceptualizes reconstruction as a process shaped by interactions among human, institutional, technological, and governance dimensions. This approach aligns with recent Industry 5.0 scholarship emphasizing resilience, adaptability, and ethical governance in response to systemic uncertainty and external shocks (Leng et al., 2022; From Automation to Collaboration, 2025).

Within this logic, Industry 5.0 is treated not as an end-state of industrial evolution, but as a context-sensitive pathway that can be strategically aligned with reconstruction objectives. By embedding Industry 5.0 principles within a post-conflict analytical lens, the framework addresses a key limitation identified in recent reviews—namely, the lack of integrative models capable of linking industrial transformation with societal recovery and institutional rebuilding (Leadership Perspectives on Industry 5.0, 2024).

Case orientation and transferability. Syria is employed as an illustrative case to contextualize the framework and demonstrate its relevance in a prolonged post-conflict environment characterized by economic disruption, weakened institutions, and social fragmentation. The Syrian case highlights the limitations of technology-driven recovery models and underscores the importance of employment-intensive, human-centered, and socially inclusive approaches (UNDP, 2023). Importantly, the study does not aim to empirically assess Industry 5.0 implementation in Syria. Instead, Syria serves as an analytical reference point that grounds the framework in real-world reconstruction challenges while preserving its theoretical transferability to other post-conflict and fragile contexts.

As a conceptual study, this research does not empirically test the proposed framework. This constitutes a methodological limitation but also reflects a deliberate choice aligned with the study's theory-building objectives. Conceptual frameworks play a critical role in structuring future empirical research, particularly in emerging domains where analytical clarity precedes measurement (Jaakkola, 2020). Additionally, Industry 5.0 remains an evolving research field. While this introduces a degree of conceptual fluidity, grounding the framework in the most recent literature and emphasizing adaptability mitigates this limitation and supports its relevance for ongoing scholarly and policy debates.

4. Integrative Conceptual Framework: Overall Structure and Logic

This study proposes a human-centered conceptual framework that positions Industry 5.0 as a pathway for economic and social reconstruction in post-conflict Syria. The framework is designed to address the structural, institutional, and human challenges that characterize fragile and post-conflict environments,

where conventional models of industrial development and technological transformation often prove insufficient. Rather than treating Industry 5.0 as a technologically advanced stage of industrial evolution, the framework conceptualizes it as a normative and strategic development paradigm grounded in human well-being, sustainability, and social inclusion. The framework adopts a three-layer analytical structure that reflects established traditions in systems theory, development economics, and innovation studies. These layers include a normative-principled layer grounded in Industry 5.0 values, an operational-institutional layer that translates principles into reconstruction mechanisms, and an outcome-oriented layer that captures economic and social reconstruction results.This layered structure reflects the assumption that sustainable reconstruction outcomes cannot be achieved through direct technological adoption alone, but rather through mediating institutional and human mechanisms that align innovation with societal needs. Similar multi-layer approaches are widely used in sustainability transitions (Geels, 2002), innovation systems theory (Lundvall, 1992), and post-conflict development literature (Collier et al., 2003). Figure 2 illustrates an integrative human centered conceptual model for Syrian Post-Conflict Context

The first layer: Industry 5.0 core principles (normative foundation). The first layer of the framework establishes the normative foundation guiding reconstruction efforts. It defines the values and principles that shape how economic and technological development should occur in post-conflict contexts. This layer draws primarily on the emerging theoretical literature on Industry 5.0, which emphasizes a shift from efficiency-driven industrial models toward human-centered, sustainable, and resilient development (European Commission, 2021; Breque et al., 2021). These pillars: Human centricity, sustainability, and resilience, have been consistently identified in recent systematic reviews and conceptual analyses as defining characteristics of Industry 5.0 (Alves et al., 2023; Leng et al., 2022; European Commission, 2021).

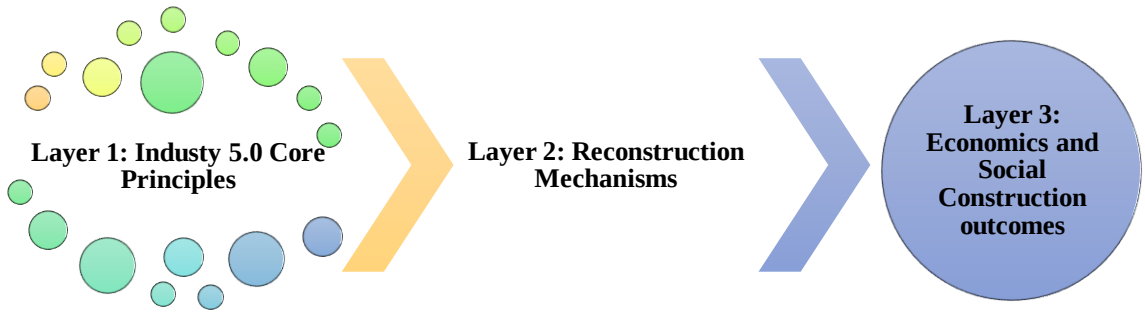

Figure 2. Integrative Conceptual Framework for Industry 5.0

Human-centricity repositions humans as active agents within production and innovation systems rather than passive beneficiaries or replaceable labor inputs. Recent literature stresses that Industry 5.0 emphasizes human–machine collaboration, where technology augments human skills, creativity, and decision-making instead of displacing labor (Alves et al., 2023; Xu et al., 2023). In post-conflict contexts such as Syria—where unemployment, skills erosion, and social exclusion are prevalent—this principle is particularly critical. Human-centered industrial strategies can support employment-intensive recovery, inclusive participation, and the rebuilding of human capital, aligning technological advancement with social needs rather than

technological determinism. Industry 5.0 is conceptualized as prioritizing human well-being over productivity maximization, positioning technology as a tool that enhances human capabilities rather than replacing labor. This perspective is particularly relevant in post-conflict environments such as Syria, where unemployment, skills erosion, and social exclusion represent critical challenges. By emphasizing human–machine collaboration, Industry 5.0 aligns with human-centered development theory, notably Sen's capability approach, which defines development as the expansion of people's freedoms, agency, and opportunities (Sen, 1999; Sen, 2009).

Sustainability constitutes a second core principle within this layer. Drawing on sustainability science and transition theory, sustainability is understood not merely as environmental protection, but as the capacity to maintain economic, social, and ecological systems over time (Brundtland Commission, 1987; Geels, 2011). Recent Industry 5.0 research explicitly links sustainability to responsible innovation, circular economy principles, and long-term societal well-being (Martini et al., 2024; Müller, 2025). In post-conflict settings, environmental degradation often accompanies economic collapse, making sustainable reconstruction essential for long-term resilience.

Resilience forms the third pillar and reflects the capacity of systems to absorb shocks, adapt to uncertainty, and recover from disruption. Recent studies emphasize resilience as a defining dimension of Industry 5.0, particularly in response to global crises, geopolitical instability, and supply-chain vulnerabilities (Leng et al., 2022; From Automation to Collaboration, 2025). For post-conflict Syria, resilience is not merely technical but institutional and social. Embedding resilience within industrial and economic systems enables adaptive reconstruction pathways capable of responding to political, economic, and social volatility.

Together, these three principles provide the ethical and normative anchor of the conceptual framework, ensuring that reconstruction efforts prioritize human dignity, social inclusion, and sustainable development.

The principles of social inclusion and decent work further anchor the framework in ethical and social considerations. Post-conflict economies are frequently marked by inequality, marginalization, and informal labor markets. Industry 5.0 explicitly addresses these concerns by promoting inclusive innovation and dignified employment (European Commission, 2021). Finally, ethical governance and responsible innovation are emphasized to ensure that technological and economic decisions contribute to social trust and institutional legitimacy—both of which are often weakened in fragile states (UNDP, 2022). Together, these principles define Industry 5.0 as a value-driven paradigm capable of guiding reconstruction beyond purely economic recovery.

The second layer: reconstruction mechanisms (operational and institutional translation). The second layer of the framework translates Industry 5.0 principles into concrete reconstruction and operational mechanisms. This layer functions as a bridge between normative values and development outcomes, recognizing that principles alone cannot generate change without institutional and operational pathways. Recent Industry 5.0 literature highlights that achieving human-centered and sustainable outcomes requires coordinated interaction between institutions, technology, skills, and governance structures (Martini et al., 2024; Xu et al., 2023).

At the institutional level, universities, vocational education systems, SMEs, and public institutions play a central role in facilitating Industry 5.0 transitions. Recent research underscores the importance of education and reskilling in enabling human-centric industrial models, particularly through lifelong learning, digital literacy, and adaptive skills development (Exploring Human-Centricity in Industry 5.0, 2024). In post-conflict Syria, universities and training institutions can act as anchors of reconstruction, supporting skills regeneration, innovation diffusion, and social trust-building.

Central to this layer is human capital development and reskilling, which is widely recognized as a cornerstone of post-conflict recovery. Armed conflict disrupts education systems and erodes skills, limiting productive capacity and employment opportunities. Human capital theory and post-conflict development

studies emphasize the role of education, training, and lifelong learning in restoring economic functionality and social mobility (World Bank, 2018; UNDP, 2022). Within the Industry 5.0 framework, reskilling is oriented toward adaptive, context-appropriate technologies that complement human labor.

Small and medium-sized enterprises (SMEs) and community-based production systems constitute a second key mechanism. Institutional economics and development literature highlight SMEs as primary engines of employment and local economic recovery in fragile contexts (North, 1990; UNIDO, 2020). Unlike capital-intensive industrial models, SME-led development aligns with Industry 5.0's emphasis on human-scale production and local value creation.

The framework further incorporates human–machine collaboration at an appropriate scale, rejecting automation-heavy approaches associated with Industry 4.0. Instead, technology adoption is conceptualized as incremental and adaptive, shaped by social needs and institutional capacity. This aligns with socio-technical systems theory, which emphasizes the co-evolution of technology, institutions, and society (Geels, 2002).

University–industry–society partnerships represent another critical mechanism within this layer. Drawing on innovation systems theory and the Triple Helix model, universities are positioned as central actors in post-conflict reconstruction through knowledge production, skills development, and trust-building (Lundvall, 1992; Etzkowitz & Leydesdorff, 2000). In Syria, higher education institutions can function as stabilizing institutions that connect innovation with social reconstruction.

Technological systems in Industry 5.0 are characterized by adaptive, flexible, and context-sensitive technologies, rather than capital-intensive automation. Human-centered AI, collaborative robotics, and digital platforms are increasingly framed as tools that empower workers and communities when embedded within ethical governance frameworks (Martini et al., 2024). This aligns with the needs of post-conflict economies, where large-scale automation may be neither feasible nor socially desirable.

Governance and policy frameworks constitute a further enabling dimension. Recent policy-oriented research emphasizes that Industry 5.0 requires inclusive, participatory, and ethically grounded governance models to ensure alignment between technological innovation and societal goals (European Commission, 2021; Leadership Perspectives on Industry 5.0, 2024). In fragile contexts, such governance mechanisms are essential for rebuilding institutional legitimacy, fostering stakeholder participation, and reducing social fragmentation.

Finally, institutional rebuilding and policy alignment underpin all reconstruction mechanisms. Institutional economics emphasizes that inclusive and effective institutions are prerequisites for sustainable development (Acemoglu & Robinson, 2012). In post-conflict contexts, rebuilding governance structures and aligning policies with human-centered development goals are essential for translating Industry 5.0 principles into practice.

The third layer: economic and social reconstruction outcomes. The third layer of the framework captures the intended outcomes of applying Industry 5.0 in post-conflict Syria. These outcomes reflect a multidimensional understanding of reconstruction that goes beyond short-term economic indicators. Employment generation and livelihood restoration represent primary outcomes, consistent with post-conflict reconstruction literature that identifies employment as a key driver of stability and peace (Collier et al., 2003). Beyond employment, the framework emphasizes social cohesion and trust-building, recognizing that economic recovery alone cannot sustain peace without social integration and institutional legitimacy (Putnam, 2000; OECD, 2011).

Inclusive economic growth is conceptualized as growth that benefits diverse social groups and regions, reducing inequality and marginalization. Environmental recovery and sustainability are included to ensure that reconstruction does not reproduce ecological vulnerabilities. Finally, institutional resilience is

emphasized as the capacity of economic and governance systems to adapt to future shocks, drawing on resilience theory and sustainability science (Folke et al., 2010).

Economically, the framework supports inclusive growth, SME revitalization, and employment generation through human-centered production models. Recent studies indicate that Industry 5.0-oriented strategies can enhance economic resilience by promoting localized value chains and reducing dependency on vulnerable global supply networks (From Automation to Collaboration, 2025). Socially, the framework contributes to social cohesion, trust-building, and empowerment. By emphasizing participation, dignity, and collaboration, Industry 5.0 aligns economic recovery with social reconciliation—an essential requirement in post-conflict societies (Alves et al., 2023). Environmentally, the framework aligns reconstruction with sustainable development goals, supporting responsible resource use and long-term ecological balance (Müller, 2025).

Integrative logic of the framework. Taken together, the three layers form an integrated conceptual model in which Industry 5.0 principles shape reconstruction mechanisms, which in turn generate sustainable economic and social outcomes. The framework demonstrates that Industry 5.0 can be meaningfully adapted to post-conflict contexts when understood as a human-centered development philosophy rather than a technologically deterministic model. By embedding ethical values, institutional mediation, and sustainability within a single structure, the framework offers a theoretically grounded pathway for reconstruction in Syria and other fragile environments. The strength of this conceptual framework lies in its integrative logic. Rather than treating Industry 5.0 as a technological endpoint, the model conceptualizes it as a context-sensitive development pathway. Recent reviews consistently highlight the lack of integrated frameworks capable of translating Industry 5.0 principles into post-crisis or post-conflict contexts (Leadership Perspectives on Industry 5.0, 2024). By bridging this gap, the framework offers a novel contribution to both Industry 5.0 scholarship and post-conflict development literature.

5. Discussion

The integrative conceptual framework proposed in this study responds to a critical gap in the Industry 5.0 literature: the absence of models explicitly designed for post-conflict reconstruction contexts such as Syria. While recent scholarship has made significant progress in defining Industry 5.0 as a human-centered, sustainable, and resilient paradigm, most existing frameworks remain grounded in stable, industrialized economies and manufacturing-centric environments. This limitation is particularly consequential for Syria, where reconstruction challenges extend far beyond industrial productivity to include institutional fragility, labor market collapse, social fragmentation, and environmental degradation.

Recent Industry 5.0 models have primarily focused on normative principles and technological-human interaction. For example, Xu et al. (2023) conceptualize Industry 5.0 as an evolution from Industry 4.0 that rebalances automation with human creativity and social value. While their framework is influential in defining paradigm boundaries, it implicitly assumes functioning institutions, advanced industrial infrastructure, and stable governance conditions—assumptions that do not hold in Syria's post-conflict economy. As such, the Syrian case exposes a structural limitation in many existing models: they conceptualize Industry 5.0 as a next stage rather than a reconstruction logic.

Similarly, Alves et al. (2023) synthesize Industry 5.0 literature around three pillars—human-centricity, sustainability, and resilience—but stop short of modeling how these pillars interact with post-conflict economic realities, such as informal labor markets, destroyed production capacity, and displaced human capital. In Syria, where reconstruction must prioritize employment generation, SME revitalization, and social trust rebuilding, a purely principle-based framework is insufficient. The proposed integrative framework addresses this gap by embedding Industry 5.0 principles within a three-layer structure that explicitly links values to mechanisms and outcomes relevant to Syria's recovery trajectory.

More recent sustainability-oriented models move closer to the concerns addressed in this study but still lack contextual specificity. Martini et al. (2024) propose a human-centered AI and sustainability framework for Industry 5.0, emphasizing ethical governance and environmental responsibility. While highly relevant, their model presumes the presence of regulatory capacity and digital governance infrastructures that are severely weakened in Syria. By contrast, the proposed framework reconceptualizes governance as adaptive and rebuilding-oriented, recognizing that in Syria, institutional reconstruction and economic recovery must proceed simultaneously.

Resilience-focused frameworks also offer partial insights. Leng et al. (2022) frame Industry 5.0 as a pathway toward resilient manufacturing systems capable of absorbing shocks. However, resilience in Syria cannot be limited to production systems; it must encompass societal resilience, including reintegration of displaced populations, restoration of livelihoods, and rebuilding of community-level trust. The integrative framework expands the notion of resilience from an operational concept to a systemic socio-economic property, aligning more closely with Syria's post-conflict needs.

Emerging transition-oriented models acknowledge the need for broader integration but remain underdeveloped for fragile contexts. Recent work on Industry 5.0 and sustainability transitions (e.g., Kumar et al., 2024) emphasizes circular economy principles and collaborative value creation. While these dimensions resonate strongly with Syria's need for resource-efficient reconstruction and local production, such models often overlook conflict legacies and power asymmetries that shape post-war economies. The Syrian case demonstrates that sustainability transitions cannot be technologically driven alone; they must be socially negotiated and institutionally supported—an insight explicitly operationalized in the proposed framework.

What distinguishes the proposed integrative conceptual framework is its context-sensitive architecture. Rather than adapting an existing Industry 5.0 model to Syria post hoc, the framework is constructed from the realities of post-conflict reconstruction. Its three-layer logic—(1) foundational principles, (2) enabling socio-technical and institutional mechanisms, and (3) reconstruction-oriented outcomes—reflects the interdependence of economic recovery, social cohesion, and environmental sustainability in Syria. This structure aligns with recent calls for Industry 5.0 models that move beyond manufacturing optimization toward societal transformation (European Commission, 2023).

Importantly, the framework reframes Industry 5.0 not as a high-tech ambition but as a human-centered development philosophy suited to incremental reconstruction. In Syria, where advanced automation may exacerbate unemployment and inequality, the emphasis on human–machine collaboration, skills regeneration, and SME empowerment offers a more inclusive pathway. This positioning advances the literature by demonstrating that Industry 5.0 can be meaningfully applied in low-capacity, post-conflict environments—an application largely absent from prior models.

In sum, while existing Industry 5.0 frameworks provide valuable conceptual foundations, they insufficiently address the structural conditions of post-conflict economies. By placing Syria at the center of analysis, this study extends Industry 5.0 theory into a new domain, proposing an integrative model that bridges industrial transformation, social reconstruction, and sustainable development. This contribution not only enriches Industry 5.0 scholarship but also opens new research pathways for applying human-centered industrial paradigms in fragile and conflict-affected contexts.

Research limitations and future research directions. While this study makes a theoretical contribution by developing an integrative conceptual framework for applying Industry 5.0 to Syria's post-conflict reconstruction, several limitations should be acknowledged. Importantly, these limitations arise not from methodological weakness, but from the deliberate choice to adopt a theory-building rather than theory-testing approach, which is appropriate given the nascent state of Industry 5.0 research in fragile and conflict-affected contexts.

First, the conceptual nature of the study implies that the proposed framework has not been empirically tested. Although the framework is grounded in recent Industry 5.0 literature and informed by post-conflict reconstruction theory, its relationships and assumptions remain analytically derived rather than statistically validated. As such, causal linkages among human-centered principles, enabling mechanisms, and reconstruction outcomes are theoretically reasoned rather than empirically confirmed. This limitation reflects a broader characteristic of emerging theoretical fields, where conceptual clarity must precede large-scale empirical validation (Dubin, 1978; Whetten, 1989).

Second, the framework is contextually anchored in the Syrian post-conflict environment, which enhances its relevance but also limits its immediate generalizability. Syria represents a complex case characterized by prolonged conflict, institutional fragmentation, and economic sanctions. While these conditions make Syria a critical and underexplored case for Industry 5.0 theory development, they also imply that the framework may require contextual adaptation before being applied to other post-conflict or fragile settings. This limitation underscores the context-sensitive nature of theory-building, particularly in socio-technical and development-oriented research.

Third, the study does not specify measurable indicators or operational variables for each component of the framework. This omission is intentional, as premature operationalization could constrain conceptual flexibility and risk misalignment with evolving Industry 5.0 interpretations. However, the absence of defined metrics limits the framework's immediate applicability for empirical evaluation or policy benchmarking. As a result, the framework should be viewed as an analytical scaffold rather than a finalized evaluative tool.

These limitations directly inform several directions for future research. Most importantly, subsequent studies should adopt theory-testing and theory-refining approaches to empirically validate and extend the proposed framework. Quantitative research designs—such as structural equation modeling or system dynamics modeling—could be employed to test the hypothesized relationships between Industry 5.0 principles, institutional mechanisms, and socio-economic reconstruction outcomes in Syria or comparable post-conflict contexts. Such studies would contribute to establishing the framework's explanatory and predictive power.

Qualitative and mixed-methods research also offers valuable avenues for theory testing and refinement. In-depth case studies of Syrian SMEs, vocational training initiatives, or community-based innovation programs could assess how human–machine collaboration, skills regeneration, and adaptive governance operate in practice. Comparative studies across post-conflict settings in the Middle East or other regions could further test the framework's transferability and identify context-specific adaptations.

Finally, future research could operationalize the framework into policy evaluation tools or maturity models, enabling policymakers and development actors to assess reconstruction initiatives through an Industry 5.0 lens. Longitudinal studies would be particularly valuable in examining how Industry 5.0–inspired reconstruction pathways evolve over time and respond to shifting political, economic, and technological conditions.

In sum, while the theory-building approach adopted in this study limits empirical validation, it simultaneously creates a structured foundation for systematic theory testing. By explicitly articulating these limitations, the study positions itself as a starting point for a broader research agenda aimed at empirically grounding Industry 5.0 as a viable paradigm for post-conflict reconstruction.

6. Conclusions

This study set out to address a critical theoretical and practical gap in the Industry 5.0 literature: the lack of conceptual models explicitly tailored to the realities of post-conflict reconstruction. By focusing on Syria as a central case, the paper demonstrates that Industry 5.0 cannot be meaningfully understood or applied as a

technologically deterministic progression beyond Industry 4.0. Instead, it must be reframed as a human-centered, sustainability-oriented development philosophy capable of operating under conditions of institutional fragility, economic disruption, and social fragmentation. The integrative conceptual framework developed in this study synthesizes three interdependent layers—foundational principles, enabling mechanisms, and reconstruction-oriented outcomes—into a coherent structure aligned with Syria's post-conflict needs. In contrast to existing Industry 5.0 models that emphasize manufacturing optimization or advanced automation, this framework foregrounds employment generation, SME empowerment, skills regeneration, adaptive governance, and social cohesion. In doing so, it extends Industry 5.0 theory beyond stable industrial environments and positions it within broader debates on reconstruction, resilience, and sustainable development. The discussion highlighted that while recent Industry 5.0 scholarship has advanced normative clarity around human-centricity, sustainability, and resilience, it remains largely detached from fragile contexts. The Syrian case underscores the limitations of universalized models and illustrates the necessity of context-sensitive frameworks that integrate technological, institutional, and societal dimensions. By embedding Industry 5.0 within a post-conflict reconstruction logic, this study provides a theoretical bridge between industrial transformation literature and post-conflict development studies. From a policy perspective, the framework offers guidance for designing reconstruction strategies that avoid automation-led exclusion and instead promote inclusive, labor-intensive, and environmentally responsible growth. It suggests that Industry 5.0–inspired interventions in Syria should prioritize local production systems, community-based innovation, and human–machine collaboration aligned with social objectives. Future research should empirically test the proposed framework through sectoral case studies, comparative analyses across post-conflict contexts, and policy evaluation research. Such work would further refine the applicability of Industry 5.0 as a reconstruction paradigm and contribute to evidence-based policymaking in fragile and conflict-affected economies.

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