



RESEARCH ARTICLE

Adopting Industry 4.0: A Strategic Solution for Transforming Smart Bangladesh: Prospective Connections, Opportunities, and Challenges

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ABSTRACT

Industry 4.0 is involving with the impact of diverse sectors such as manufacturing, education, government, citizen, economy, healthcare, agriculture and among others for transforming smart Bangladesh. The study aspires to determine the connection between industry 4.0 and smart Bangladesh by adopting the strategic solutions in diverse areas. Moreover, this research involves with opportunities and challenges of adopting it for making a smart nation. The study involved an extensive exploration of many electronic databases, including Web of Science, Scopus, Science Direct, Research gate, and Google Scholar, among others. However, the choice of journals for the review exhibited a bias towards renowned publishing journals such as Emerald, Elsevier, Taylor & Francis, and MDPI etc. The issues encompass inadequate data, publications composed in diverse languages, divergent outcomes, and unrelated effects and findings. After a screening procedure, researcher has identified 11 additional papers that satisfy the requirements for inclusion in the research. For identifying and fulfilling the research gaps, this study conducted on a comprehensive analysis of the topic and potential benefits as well as obstacles that may arise in the process. By exploring these factors, this paper aims to contribute to the existing body of knowledge and provide valuable insights for policymakers, researchers, and stakeholders involved in the development of Smart Bangladesh. In the future, researchers could perform longitudinal studies to examine the evolution of industry 4.0 and smart Bangladesh across time. Future research can offer more comprehensive, advanced, and applicable insights into the evolving domain of connection, possibilities, challenges, and strategic directions for transforming smart Bangladesh by acknowledging and overcoming these limitations and exploring the suggested future possibilities.

INTRODUCTION

The Fourth Industrial Revolution (4IR) or Industry 4.0 was driven by the need for increased production and higher efficiency (Amin et al., 2024). Alongside these needs, there is a growing demand for greater corporate transparency and detailed monitoring of operations and production lines. The Internet of Things (IoT) has transformed the new ecosystem into a highly data-driven environment, generating vast amounts of data in various forms (Meah & Hossain, 2023). Much of this data is processed and stored in cloud computing systems. Real-time monitoring is crucial, and precise forecasts and predictive analytics are essential for informed decision-making.

Advanced systems capable of automatically responding to changing conditions, powered by machine learning and artificial intelligence, and are now possible. Additionally, drones, autonomous vehicles,

and robotics have taken over many dangerous and hazardous tasks previously performed by humans (Poli et al., 2024). Overall, the Fourth Industrial Revolution (4IR) enhances quality of life and minimizes environmental impact by increasing productivity and efficiency with fewer resource requirements (Bhuiyan et al., 2023).

There are hazards associated with every opportunity, and the Fourth Industrial Revolution (4IR) (Amin et al., 2024). Despite being minimal, the challenges are substantial. Although human resources won't go out of style, many current skill sets will eventually become outdated. However, more complex and control-oriented tasks like monitoring, quality assurance, and decision-making will still require human knowledge (Mani, 2019). All three of the past industrial revolutions were preceded by fears of significant employment losses, fears that have turned out to be baseless. In the end, every revolution has raised social indicators, raised living standards, and increased employment prospects (Islam & Bhuiyan, 2022).

Researchers claimed that there are many infrastructure problems that impede Bangladesh's adoption of automation, including inadequate broadband internet connectivity, limited communication and transportation facilities, and the regular occurrence of floods and other natural catastrophes. According to Bandyopadhyay et al (2020), these difficulties also make it more difficult for the nation to gain from Industry 4.0. Another important factor is the availability of inexpensive labor (Masum et al., 2024).

Bangladesh is embracing innovative technologies in a number of sectors to propel socioeconomic development, even in the face of several obstacles like low awareness, scarce funding, a surplus of inexpensive labor, inadequate digital infrastructure, skill shortages, and more general socioeconomic problems (Prosvetova & Gerasimov, 2020). But in the last few years, the public and private sectors have started working to improve infrastructure and increase financial, technological, and human resources (Bovaird & Klijn, 2023).

Research gaps

Every opportunity carries some risks, and the Fourth Industrial Revolution (4IR) is no exception (Mia et al., 2024). While the challenges may be few, they are significant. Human resources remain essential, yet many current skill sets will eventually become outdated (Bhuiyan et al., 2023a). Nonetheless, human expertise will still be necessary for complex, control-oriented tasks such as quality assurance, monitoring, and decision-making (Amin et al., 2024). Each of the previous three industrial revolutions was initially met with fears of widespread job losses, but these fears proved to be unfounded. In fact, every revolution has ultimately led to improved social indicators, enhanced living standards, and increased job opportunities (Bhuiyan & Akter, 2024). This gap in the literature assumes greater importance when considering the context of industry 4.0, which encompasses substantial transformations in work practices, as well as the case of Smart Bangladesh because there are limited work in this field (Kabir et al., 2024). Therefore, research gaps exist regarding the prospective connections, opportunities, and challenges associated with the adoption of Industry 4.0 in the context of transforming Bangladesh into a smart nation (Amin et al., 2024). This study aims to address these gaps and provide strategic solutions for the successful implementation of Industry 4.0 in Bangladesh.

Objectives

R01: To determine the connection between Industry 4.0 and Smart Bangladesh,

R02: To identify the opportunities and challenges of adopting Industry 4.0 for transforming Smart Bangladesh.

R03: To determine the strategic solutions for overcoming the challenges for making Smart Bangladesh.

Literature Review

Industry 4.0

The Fourth Industrial Revolution, also referred to as Industry 4.0, denotes the era wherein emerging technologies like AI, IoT, robotics, and Big Data have revolutionized industrial operations (Shorman,

2022). This involves the adoption of digital innovations to overall various of industrial processes (Bhuiyan et al., 2023b). The impact of the 4IR extends beyond the IT sector to encompass domains such as education, agriculture, manufacturing, healthcare, economy and services among others (Kowch, 2021). It not only revolutionizes manufacturing practices but also the global by enhancing access to services and restructuring the workforce. According to Rai & Yadav (2023), Industry 4.0 represents a shift from traditional production systems to intelligent, interconnected manufacturing setups termed as "Smart Production," "Smart Manufacturing," "Integrated Industry," "Connected Industry," or "Industrial Internet." This evolution necessitates the deployment of intelligent systems, refined engineering practices, and associated tools to facilitate seamless coordination among distributed manufacturing equipment (Najibi et al., 2021).

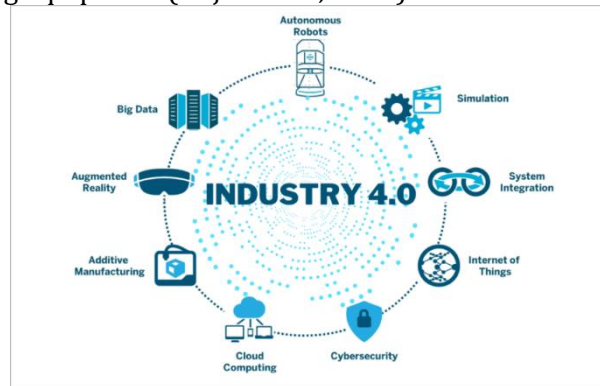


Figure 1: Concept of Industry 4.0

The concept of the "Fourth Industrial Revolution" (4IR) emerged around the middle of the last decade (Ali et al., 2023), but it has gained significant recognition and popularity in the past two years (Bhuiyan, 2024). As analysts evaluate the impact of 4IR, factories are already incorporating various advanced technologies. These include 3D printing, block chain, IoT, cloud computing, robotics, data science, AI, AR, and VR (Bhuiyan & Akter, 2024).

Smart Bangladesh

SB refers to the utilization of advanced technologies and cutting-edge innovations to enhance various societal (Raja, 2023). Overall, globalization reduces manufacturing costs, enabling businesses to offer customers lower-priced products. A major contributor to improving the standard of living is the average cost of goods (Schütze & Wichardt, 2023). Embracing Industry 4.0 leads to increased unit output by reducing manufacturing costs and enhancing production efficiency (Hossain et al., 2024).



Figure 2: Concept of Smart Bangladesh

The Fourth Industrial Revolution encompasses the Automation Age, where machines replace "low-skilled" labor. Bangladesh, a developing country in South Asia, is striving to incorporate Industry 4.0 technologies (Joseph & Buthelezi, 2022). The several essential elements of the Fourth Industrial Revolution are being used globally.

Table 1: Prospective Areas of Industry 4.0 in Smart Bangladesh

| Prospective Areas | Description | Source |
|---|--|------------------------------|
| Cyber-physical systems | The confluence of physical and virtual systems facilitates immediate data monitoring and analysis, thereby enabling streamlined decision-making and robotization within artificial operations. | (Hanratty, 2023) |
| Internet of Things | The interconnectedness of palpable bias and objects enables the sharing of data and communication among machines, fostering enhanced effectiveness and synchronization within artificial systems. | (Li, 2024) |
| Cloud computing | Leveraging remote servers for data storage and processing facilitates convenient access, scalability, and adaptability in handling extensive volumes of information and applications. | (Peng et al., 2022) |
| Cognitive computing and artificial intelligence | The deployment of sophisticated algorithms and machine learning methodologies empowers machines to analyze and decipher data, autonomously make decisions, and continually enhance their performance through iterative learning processes. | (Yang, 2023) |
| Big data analytics | The capacity to gather and analyze extensive sets of structured and unstructured data in real-time enables the detection of patterns, trends, and valuable insights, which in turn can fuel innovation and facilitate well-informed decision-making across diverse industries. | (Mohapatra & Mishra, 2024) |
| Advanced robotics | Utilizing intelligent machines and robots capable of executing intricate tasks with accuracy and effectiveness minimizes human involvement, thereby bolstering productivity in manufacturing and other industrial operations. | (Jiang, 2022; Bhuiyan, 2023) |
| Edge computing | Positioning computational power and storage resources closer to the network's edge facilitates immediate processing and analysis of data at its origin, thereby diminishing latency and enhancing response times within industrial processes. | (Bhuiyan & Akter, 2024) |
| Robotics and automation | Incorporating robotic systems and automated technologies elevates efficiency in production, ensures quality control, and enhances safety within industrial environments. | (Lee et al., 2018) |
| Cybersecurity | As connectivity and data exchange continue to expand in the 4IR, safeguarding industrial systems, networks, and data becomes increasingly crucial. | (Damasco et al., 2023) |
| Additive manufacturing | Utilizing layer-by-layer material addition to fabricate three-dimensional objects allows for rapid prototyping, customization, and production of intricate designs across diverse industries, thereby transforming conventional manufacturing methods. | (Iglesias, 2023) |

The research critically analyzes the prospects and problems for implementing Industry 4.0 in Bangladesh and provides requirements of skills for its continuous improvement (Bhuiyan & Akter, 2024).

METHODOLOGY

A systematic review is a rigorous and organized method of reviewing literature. It entails following a well-defined protocol and doing a thorough evaluation of a set of research articles through a multi-

stage review process (Molla et al., 2023). The main goal of this systematic analysis is to examine the potential connections, opportunities, and challenges associated with implementing Industry 4.0 as a strategic solution for transforming Bangladesh into a smart country (Islam et al., 2024). The utilization of the systematic review technique facilitated the discovery of pertinent literature by following precise methods intended to select and present research findings that are in line with the objectives of the study (Bhuiyan, 2017).

This study employs an empirical methodology, utilizing empirical evidence and relevant theories to substantiate explanations and arguments (Rahman et al., 2024). Within the context of this Qualitative research paradigm, the focus is on comprehending the dynamic character of reality influenced by individuals' experiences, where the researcher and participants have close and interconnected interactions (Bhuiyan et al., 2023). In addition, the research encompassed a comprehensive search across multiple electronic databases, such as Web of Science, Scopus, Science Direct, Research gate, and Google Scholar, among others. Nevertheless, the selection of journals for the review was biased towards well-known publishing houses such as Emerald, Elsevier, Taylor & Francis, and MDPI (Bhuiyan et al., 2024). The decision was made based on their alignment with the fundamental issue of the review, as established by the research challenge (Rahman et al., 2024).

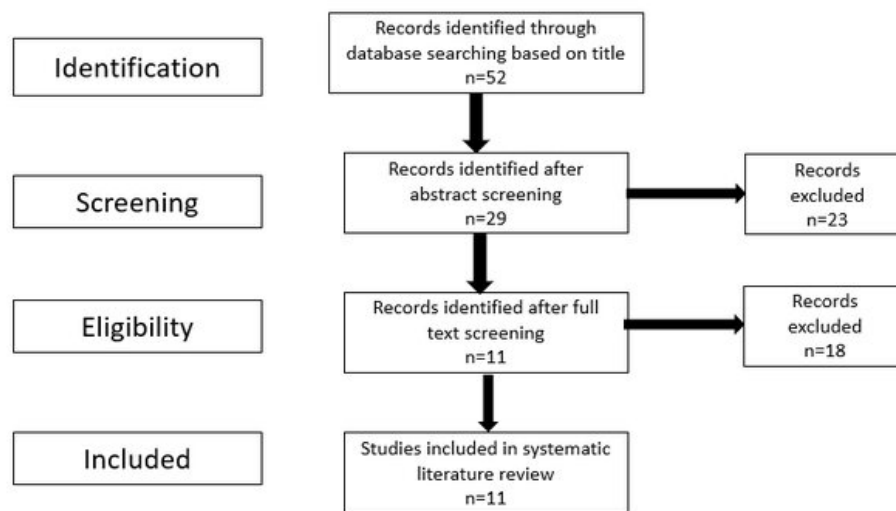


Figure 3: A Systematic Methodology

Source: Author's Work

The process of identification, screening, and inclusion of options is carried out by categorizing them according to specific criteria, as illustrated in Figure 3. The exclusion of any records that do not align with the specified keywords or research subject is implemented (Bhuiyan, 2017). When evaluating publications and reports, several factors are considered in the decision to reject them. These factors include insufficient data, papers written in different languages, varying outcomes, and unrelated effects and results. The rigorous selection process has yielded the discovery of 11 supplementary papers that meet the criteria for inclusion in the study.

DISCUSSIONS

This review paper examines the various opportunities, challenges, and strategic solutions associated with the transformation of Smart Bangladesh. The aim is to provide a comprehensive analysis of the topic and shed light on the potential benefits and obstacles that may arise in the process. By exploring these factors, this paper aims to contribute to the existing body of knowledge and provide valuable insights for policymakers, researchers, and stakeholders involved in the development of Smart Bangladesh (Bhuiyan et al., 2024).

Opportunities of Industry 4.0 in Smart Bangladesh

The present study aims to explore the potential opportunities that Industry 4.0 offers in the context of a Smart Bangladesh. Industry 4.0, also known as the Fourth Industrial Revolution, is characterized by the integration of advanced technologies such as artificial intelligence, internet of things, big data analytics, and robotics into various industries. This transformative wave has the potential to revolutionize.

Table 2: Opportunities of Industry 4.0 in Smart Bangladesh

| Opportunities | Description | Reference |
|-------------------------------------|---|--|
| Sustained financial backing | This benefit extends beyond just financial resources; it also encompasses the capacity to propel or advance the enterprise forward. | (Zhang, 2023) |
| Enhanced operational efficacy | Maximizing available resources, including time, personnel, infrastructure, energy, and funding, is akin to optimizing operations to deliver goods or services profitably. Efficient operations strive to minimize waste and idle resources, ensuring that every expenditure yields a worthwhile return on investment. | (Meena et al., 2024) |
| Competitive advantages | Implementing Industry 4.0 practices can greatly enhance the competitiveness of Bangladesh's manufacturing sector. The cutting-edge technologies associated with Industry 4.0 can improve productivity, efficiency, and quality, resulting in cost reductions and higher levels of customer satisfaction. | (Ilin et al., 2022) |
| Continuous personal growth | This reinforces the concept of continuous improvement and the integration of diverse elements of growth throughout one's lifetime. | (Magwegwe & Sithole, 2024) |
| Collaborative innovation ecosystem | It indicates a landscape where external support, technological progress, and knowledge exchange are pivotal factors driving advancement and transformation in the Fourth Industrial Revolution. | (Bidisha et al., 2023) |
| Technology proficiency | The advantage of Industry 4.0 lies in the ability to utilize technology for effective and professional communication, streamlined information organization, high-quality product manufacturing, and the improvement of cognitive skills in a developing nation. | (Siwach et al., 2022; Demaine, 2022) |
| Individual creativity and ingenuity | The advantages stem from the notion that individuals can generate novel ideas and resolutions, showcasing their creative problem-solving approach and innovative thinking within the framework of Industry 4.0. | (Harris, 2023; Elbashbishy & El, 2024) |
| Agile talent development | The approach where companies invest in the development of their human resources and promote knowledge transfer among different teams or generations within the workforce, while enabling | (Shi et al., 2022; Huang & Wang, 2024) |

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| | individuals to adjust to evolving roles, can be advantageous for emerging economies. | |
| Adaptive leadership culture | This benefit reflects an adaptable and visionary leadership approach capable of guiding companies through the transition to hybrid work environments while maintaining a clear future direction. | (Agnihotri & Bhattacharya, 2022) |
| Job Creation | In Bangladesh, the integration of Industry 4.0 could generate fresh employment opportunities. There will be a demand for workers proficient in operating and maintaining advanced technologies. This transition could also enhance Bangladesh's capacity to cultivate a skilled workforce. | (Wawage & Deshpande 2023) |
| Enhanced Logistics Optimization | Industry 4.0 can improve supply chain management in Bangladesh. By integrating IoT devices and data analytics, supply chain operations can be monitored and optimized, leading to higher productivity and reduced costs. | (Liotine & Ginocchio, 2020) |
| Sustainable Manufacturing | Adopting Industry 4.0 in Bangladesh has the potential to promote environmentally friendly production methods. Advanced technologies can optimize energy and resource consumption, thereby reducing the environmental impact. | (Bertolini et al., 2024) |

Challenges of Industry 4.0 in Smart Bangladesh

The challenges associated with the implementation of Industry 4.0 in the context of a smart Bangladesh are of significant interest to researchers and policymakers alike. Industry 4.0, also known as the Fourth Industrial Revolution, refers to the integration of advanced technologies such as artificial intelligence, big data analytics, and the Internet of Things (IoT) into traditional industrial processes (Bhuiyan et al., 2024).

Table 3: Challenges of Industry 4.0 in Smart Bangladesh

| Challenges | Description | Skill Requirement | Reference |
|-----------------------------------|--|---|----------------------|
| Digital Transformation Challenges | Challenges in Digital Transformation consists of various obstacles such as high investment costs, skills shortages, limited funding, uncertain returns on investment, and concerns about data security. The advent of Industry 4.0 has introduced significant hurdles and difficulties for businesses aiming to adopt its principles and technologies within Bangladesh. | Examination, Mastery of abilities and knowledge | (Meena et al., 2024) |

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| Organizational change erosion | This problem includes both employees' reluctance to embrace new procedures or systems and inadequate funding for the infrastructure or support systems needed to facilitate smooth transitions. | Research, Technical, Organizational, and Interpersonal skills | (Bertolini et al., 2024) |
| Transformational Landscape Dynamics | Challenges in the Industry 4.0 sector for a developing nation illustrate the complex and diverse environment in which businesses operate, where multiple factors interact and influence the process of adaptation and transformation. | Comprehensive skill, Soft skill | (De & Leal, 2021) |
| Workforce Resilience and Social Policy | These implications shift the focus away from maintaining stable job conditions towards prioritizing educational reforms that encourage government investment and resource allocation to enhance workers' ability to adjust to evolving demands. | The ability to lead effectively, adapt to changing circumstances, and foster the growth and cohesion of a team. | (HERMAN, 2022) |
| Training | Bangladesh needs to prioritize ongoing efforts to enhance people's skills and knowledge to align with changing industry trends and employment requirements. | The development of non-cognitive abilities such as communication, problem-solving, and emotional intelligence. | |
| Global operational preparedness | Achieving global operational readiness poses challenges in areas such as operational technology, securing international funding, accessing international expertise, and establishing international networks. Developing nations aspiring to compete effectively on a global scale will encounter significant difficulties in achieving comprehensive readiness across various disciplines, including technological capabilities, financial expertise, cross-cultural competence, and networking skills. | The cultivation of ICT job skills, particularly for software developers, encompassing both technical and digital proficiencies. | (Zhang, 2023) |
| Labor Market Dynamics | Bangladesh faces a complex interplay of factors, including institutional dynamics shaping required skill sets, capital accumulation influencing recruitment and retention strategies, and the financial | Innovative HR Capabilities in Technological Advancement | (Balamurugan et al., 2022) |

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| | implications of labor acquisition and retention. | | |
| Career Pathway Considerations | This restricts the ability to provide a thorough evaluation of all the factors influencing a person's career decisions, including peer pressure, mental health, potential consequences, and the significance of the work, safety measures, and opportunities for growth or entry into the industry. | A holistic approach to skill development, encompassing communication | |
| Lack of Government Support | The advancement of Industry 4.0 is hindered by inconsistent government funding and support. Additionally, the deployment of Industry 4.0 is further obstructed by misalignment between government policies and regulations. | Relationship management competencies. | (Ilin et al., 2022) |
| Inadequate Infrastructure | The deployment of Industry 4.0 requires a stable and reliable infrastructure, including cloud computing, high-speed internet, and advanced data analytics. Bangladesh still has significant progress to make in developing its infrastructure, especially in rural regions. Moreover, the country faces frequent power outages and inadequate power supplies, which can disrupt the proper functioning of Industry 4.0 technologies. | Advanced Competency Suite | (Renshaw, 2021) |
| Lack of autonomous system | The lack or insufficiency of systems capable of operating autonomously or with minimal human intervention has hindered the progress of 4IR. | Data analysis, Complex cognitive functions | |
| job insecurity | In the context of Industry 4.0, workers in Bangladesh face constant uncertainty and vulnerability regarding the continuity and security of their employment. | Decision-making and Adaptability, Digital literacy | (Magwegwe & Sithole, 2024) |

ISSUES, CHALLENGES, OPPORTUNITIES AND STRATEGIC SOLUTIONS

In order to fully utilize the advantages of the Fourth Industrial Revolution (4IR), these initiatives seek to modernize education and training institutions. Thus, this paper looks at the real-world effects of these projects, pointing out potential as well as obstacles, and suggesting smart ways to take use of Industry 4.0, especially in Bangladesh (Oliver, 2022).

Table 4: Challenges of Industry 4.0 Technology Adoption

| Strategic Solutions | Description |
|--------------------------------|---|
| Awareness building | <p>Since the Fourth Industrial Revolution is still a relatively new idea, raising awareness among authorities, decision-makers, companies, industries, scholars, workers, and consumers is of utmost importance (Gillwald, 2021). Bangladesh currently has a low level of understanding regarding disruptive Industry 4.0 technologies, but raising this awareness is crucial to accelerating economic growth and bringing Bangladesh into compliance with international norms. According to Tran & Hashimoto (2022), Lack of knowledge and resources to adjust to Industry 4.0 puts workers, SMEs, industries, and the national economy at risk of losing their competitive edge. As a result, advocates and legislators ought to carry out awareness-raising campaigns including conferences, trade shows, and international training courses for interested parties.</p> |
| Capital formation | <p>Industry 4.0 promises economic gains and competitive advantages, but it also necessitates significant capital expenditure for the adaptation of smart business models and the implementation of smart economic infrastructure. However, the banking industry has been reluctant to finance high-tech firms because of their relative youth and high level of risk. Obtaining substantial funding for cutting-edge technologies is a big problem in Bangladesh, as MSMEs make up more than 90% of the corporate sector. To solve this, the government ought to provide incentives to banks to motivate them to lend enough money to the nation's high-tech sectors (Parti & Tahir, 2023).</p> |
| Socioeconomics Challenges | <p>Automation and digitization combined to create intelligent, interactive, and user-friendly machines characterize the Fourth Industrial Revolution (Shorman, 2022). These cutting-edge technologies will have a big impact on how people work. According to Krause (2019), the absence of standards, certifications, regulations, legal concerns, and data security all present difficulties. To guarantee that the Fourth Industrial Revolution is implemented in Bangladesh in an efficient manner, it is imperative that the relevant laws and regulations be developed in response to these advancements, innovations, transformations, and rising aspects.</p> |
| Training and Skill Development | <p>Consequently, a wide range of professionals' tasks—such as those of lawyers, financial analysts, physicians, journalists, accountants, insurance underwriters, and librarians—may soon be automated entirely or in part. Consequently, in order to boost investments in human capital and skills, government policymakers, academic institutions, and training facilities must move quickly (Sacopulos & Paprocki, 2022). Through long-term training, measures to create capacity, and upskilling and reskilling, this will support the industrial transition. In order to bridge the gap between education and industry and</p> |

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| | satisfy the objectives of the Fourth Industrial Revolution, these initiatives are needed (Oliver, 2022) (Agolla, 2022) (Nyerere, 2022). |
| Infrastructural Development | Important planners are also prevented from concentrating on Industry 4.0 by Bangladesh's poor infrastructure, which includes bad roads and transportation, susceptibility to natural disasters, and underdeveloped markets and technology device manufacture (Hossain, 2021). In addition, the implementation of Industry 4.0 technologies necessitates greater research and investment in a number of fields, including cybersecurity, broadband Internet deployment, IT security, and cyber legislation (Rajamäki & Tiitta, 2024). Because the new sector demands new capabilities, education will be especially impacted by this transformation. |

Industry 4.0 SEI Framework

The Skills and Employability Framework for Industry 4.0 is known as SEI. The way information systems operate is a major factor in both the possible risks and restrictions associated with information technology implementation (Aliu et al., 2021). Systems that are essential to our everyday existence, such as banking systems, air defense and strategic defense systems, and local, long-distance, and transcontinental transportation control systems, are all susceptible to failure (Skachkov et al., 2022). Although we have been enthralled with ICT's potential for a while, it is important to take into account the actual risks and constraints in it.

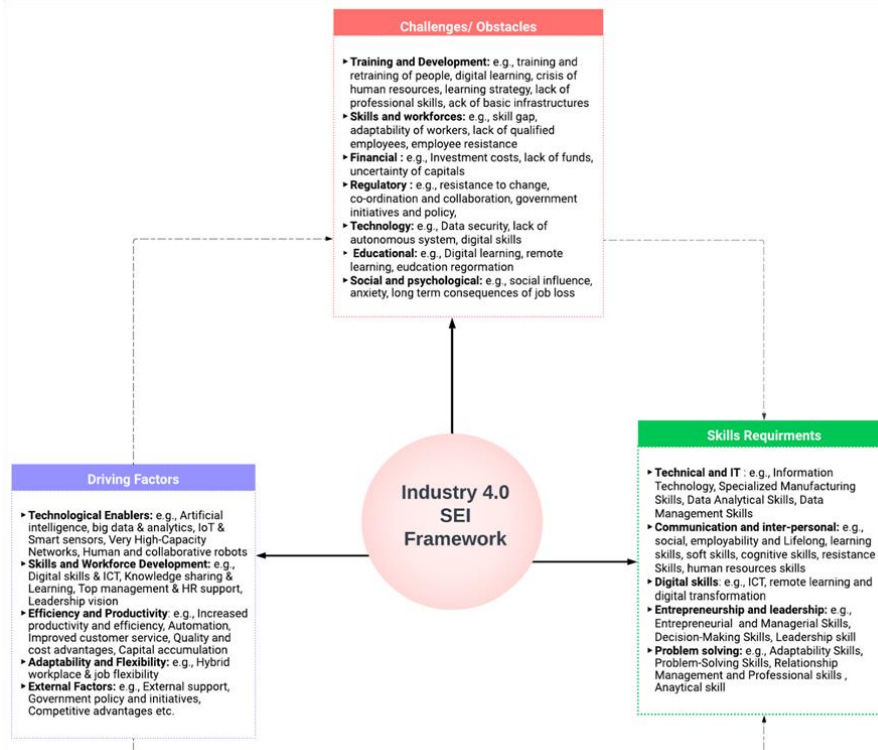


Figure 4: Industry 4.0 SEI Framework
Source: Skachkov et al. (2022)

The first area of worry is the ethics and maturity of the people using these information technologies. These two areas are closely related. Another crucial topic is security (Mang & Fernández, 2021). This

article also aims to highlight the risks associated with the widespread use of information technologies, such as those presented by the Internet of Things (IoT). Bangladesh is a developing nation, hence a sizable section of the populace is still uneducated and can be hired for cheap labor. As a result, business owners are hesitant to give up on this inexpensive labor in favor of spending money on the new buildings and equipment needed for Industry 4.0 (Jooma et al., 2019). Another significant barrier is the inadequate infrastructure of the nation.

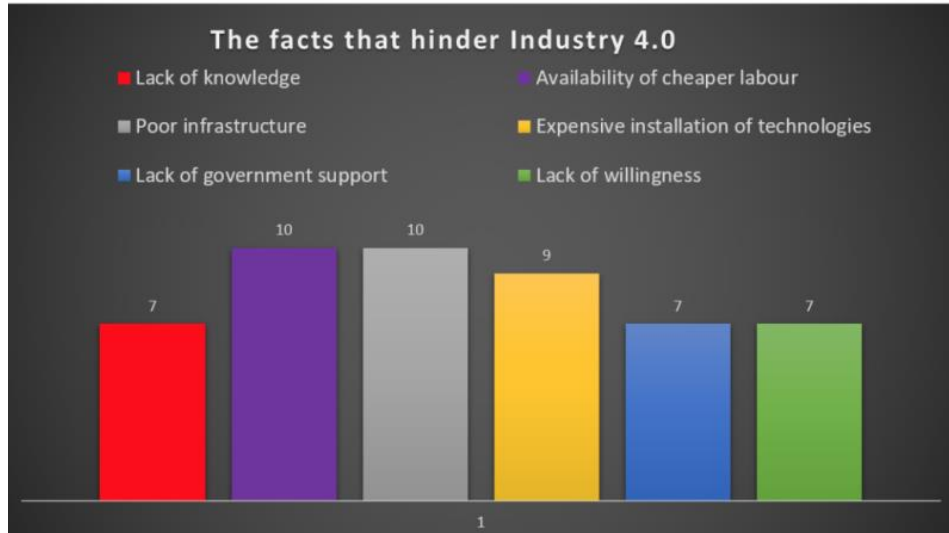


Figure 5: The challenges of Industry 4.0

Source: Jooma et al. (2019)

The Possible Outcome of Industry 4.0 If Implemented in Smart Bangladesh

Bangladesh offers great environmental advantages and human resources, therefore implementing Industry 4.0 could result in rapid economic growth (Antelman & Davis, 2021). Digitalization will be accelerated by Industry 4.0, which will also improve manufacturing, supply chains, and production. CPS, IoT, and IoS integration with ERP, PLM, SCM, MES, SAP, and other software systems will enable flexible and intelligent production (Mishra et al., 2023). The integration of big data, CPS, IoT, and artificial intelligence (AI) is encouraged by Industry 4.0 (Akter et al., 2023).

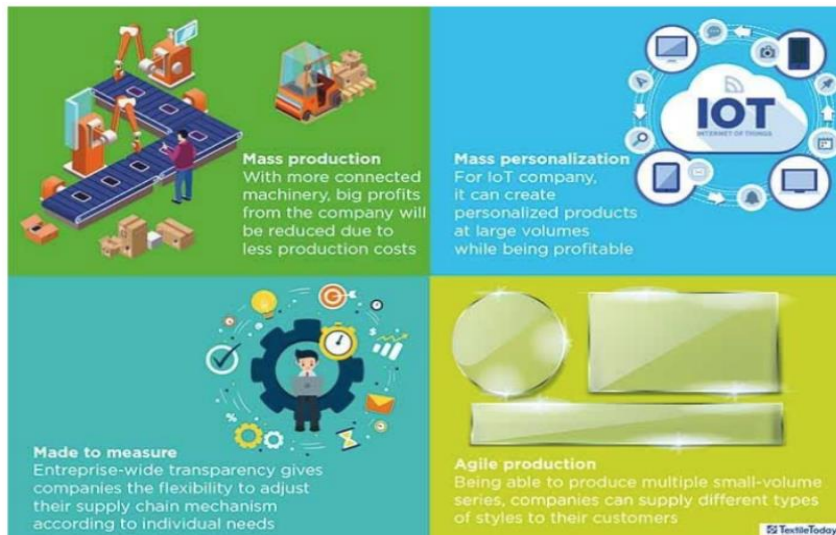


Figure 6: Possible Outcome of Industry 4.0

Source: Mishra et al. (2023)

The Possible Solutions to Overcome the Challenges

First and foremost, Industry 4.0 and its importance must be thoroughly understood by all industry players. The government and business sector should collaborate to arrange regular training sessions, workshops, seminars, and symposiums in order to accomplish this (Dubey et al., 2023). The subsequent actions are suggested for the effective execution of Industry 4.0.

Table 5: Possible Solutions to Overcome the Challenges

| Solutions | Description | Reference |
|---|---|------------------------|
| Taking measures to develop ICT infrastructure is essential for the implementation of Industry 4.0 | It is obvious that legislators, decision-makers, and industrial personnel need to step up their efforts to improve ICT infrastructure given its crucial role. The implementation and further development of automation in current production processes depend on this enhancement in order to be supported and maintained. | (Smeets, 2021) |
| Establishing and executing strategic guidelines and measures for reconfiguring manufacturing patterns | Smart production processes require a reconfiguration of manufacturing patterns in order to establish Industry 4.0. As a result, this study offers important insights that will aid in understanding and addressing the issues faced by policymakers and decision-makers. This knowledge would help Bangladesh overcome its challenges in implementing Industry 4.0 across all industries. | (Velasco et al., 2023) |
| Providing proper knowledge | Offering comprehensive education on Industry 4.0 to employees and workers to prepare them for adopting this new wave of industrial transformation. | (Poli et al., 2024) |
| Offering sufficient incentives to industrial personnel to adopt smart technologies | Businesses frequently struggle to efficiently optimize their waste resources in typical production processes. New technologies have the potential to drastically reduce energy usage and waste materials with the introduction of Industry 4.0. | (Gokhale et al., 2022) |
| Continuous upgradation of labor force | Human talents will become more and more important in the future in a variety of fields, including design, planning, quality control, maintenance, and administration. To properly adapt to technology, the current workforce must continue to upgrade their skills. To enable them to take advantage of technology breakthroughs, the workforce of the future must also be trained in critical thinking and creativity. | (Farrow, 2022) |

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| <p>System and process upgradation</p> | <p>Every system and procedure works to promote a cyclical process that aims to grow market share. Technology is essential to the implementation, oversight, and management of these procedures. Optimizing processes and automating tasks are essential for raising output and efficiency. Customers in today's world want more transparency about compliance, safety, fairness, and rights as well as real-time access to the status of their orders. To increase marketing effectiveness, businesses need to use a data-driven approach to assess client wants and market trends.</p> | <p>(Bhuiyan et al., 2023a)</p> |
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CONCLUSIONS

It's also a good idea to invite professionals from developed nations where Industry 4.0 has been effectively implemented to lead informative workshops and training sessions. It is imperative that the government take a proactive role in enabling this endeavor (Pauly & Chartock, 2022). All facets of society should be extensively informed about the significance and exigency of Industry 4.0 via radio, television, social media, the internet, newspapers, and articles. All industries should be required by law to adhere to Industry 4.0 standards (Michalis, 2021). Bangladesh runs the risk of slipping behind in the cutthroat world of Industry 4.0-driven modern industry if it does not embrace this change (Koçoğlu & Demirkol, 2020).

LIMITATIONS AND FUTURE DIRECTIONS

The study may demonstrate a publication bias, indicating a preference for papers published in esteemed journals or those that report favorable outcomes. The selection of databases, such as Scopus, Web of Science, and others, may limit inclusivity, as some relevant research might be indexed in different databases. The variability in the rigor and quality of the included research can affect the overall reliability and precision of the review's findings. To enhance the breadth of insights, next evaluations could integrate grey literature, including conference papers, dissertations, and reports (Bhuiyan, 2019). Longitudinal studies could be conducted in the future to investigate the progression of industry 4.0 and smart Bangladesh throughout time. By recognizing and surmounting these limitations and exploring the suggested future possibilities, future research can provide more comprehensive, advanced, and applicable insights into the evolving domain of connection, possibilities, challenges and strategic directions towards transforming smart Bangladesh.

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