

EXPLOITING DEMOGRAPHIC DIVIDEND FOR ENVISIONING 4IR IN BANGLADESH: OPPORTUNITIES AND POLICY CHALLENGES

(Economics/Demographic Dividend)

Research Team

Research Advisor: Dr. Md. Mohoshin Ali, MDS (Joint Secretary), BPATC

Lead Researcher: Professor Ishtiaque Selim, PhD, Jagannath University

Researcher I: Professor Sharif Mosharraf Hossain, PhD, Jagannath University

Researcher II: Razia Sultana, PhD, Senior Research Fellow, BISS

Researcher III: Mohammad Mamun, Senior Research Officer, BPATC

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Purpose of Submission

The purpose of preparing this report is to evaluate the current state of the Fourth Industrial Revolution (4IR) in Bangladesh, with a primary focus on its potential impact on the youth, and to identify key challenges and opportunities. Since key tools of 4IR, such as artificial intelligence (AI), robotics, big data, blockchain, and the Internet of Things (IoT), are transforming the global economic and administrative landscape, it is pertinent for Bangladesh to evaluate how these changes influence various social and economic sectors proactively. As Bangladesh is currently enjoying the demographic dividends, working on this area is crucial for providing some policy suggestions to the government and other concerned authorities, such as PATC, who prepare civil servants through proper training for increasing their skills and competencies. This report also seeks to support PATC's goal of enhancing the capacity building of the public sector in alignment with the demands of 4IR and other development visions of the country.

DECLARATION

We hereby declare that this study, titled "Exploiting Demographic Dividend for Envisioning 4IR in Bangladesh: Opportunities and Policy Challenges" is the result of our research and analysis. It has been thoroughly conducted by the Research Team with the greatest sincerity and full academic integrity. This study has been prepared mainly to meet the requirements of PATC, and it is an original work unless otherwise cited or referenced.

We also confirm that all sources of data, information, and literature used to prepare the report have been properly acknowledged and cited. The views and opinions presented in this report are solely those of the authors and do not necessarily represent the official policy or position of any affiliated institution or organization.

We further affirm that no part of this report has been previously submitted for any other degree, diploma, publication, or examination. In addition to that, it adheres to the ethical standards of research and reporting.

Research Team

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Finally, we take full responsibility for any errors or shortcomings that may be found in this work.

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ACRONYMS

IBA: Institute of Business Administration
AI: Artificial Intelligence
AVs: Autonomous Vehicles
BCC: Bangladesh Computer Council
BESF: Bangladesh Environmental Statistics Framework
BIDA: Bangladesh Investment Development Authority
BIDS: Bangladesh Institute of Development Studies
BPATC: Bangladesh Public Administration Training Centre
BUET: Bangladesh University of Engineering and Technology
ETP: Effluent Treatment Plant
FoF: Factory of the Future
FGD: Focus Group Discussion
HEC: Higher Education Commission
GDP: Gross Domestic Product
GID: Green Industries Diagnostic
GoB: Government of Bangladesh
ICT: Information, Communication and Technology
IIX: Impact Investment Exchange
IoMT: Internet of Medical Things
IUCN: The International Union for Conservation of Nature
IoT: Internet of Things
IT: Information Technology
ITC: International Terrestrial Cable
ITU: International Telecommunication Union
KIIs: Key Informant Interviews
KPO: Knowledge Process Outsourcing
LDCs: Least Developed Countries
LFS: Labor Force Survey

MW: Megawatt
NGOs: Non-Governmental Organization
PPP: Public-Private Partnership
POC: Proof of Concepts
RAs: Research Assistants
RMG: Readymade Garment
SIF: Service Innovation Fund
SMEs: Small and Medium Enterprises
STEM: Science, Technology, Engineering, and Mathematics
SDGs: Sustainable Development Goals
UN: United Nations
UNDP: United Nations Development Program
UGC: University Grant Commission
UIU: United International University
UK: United Kingdom
USA: United States of America
WEF: World Economic Forum
YPs: Young Professionals
4IR: Fourth Industrial Revolution

ABSTRACT

The Fourth Industrial Revolution (4IR) is reshaping global economies and societies through the integration of advanced technologies such as artificial intelligence (AI), the Internet of Things (IoT), robotics, big data, and blockchain. For Bangladesh, this technological transformation presents both significant opportunities and complex challenges, particularly in leveraging its demographic dividend. With a large and youthful population, Bangladesh possesses substantial potential to accelerate economic growth, innovation, and competitiveness through effective youth engagement in 4IR-driven development. This study explores the opportunities, challenges, and policy pathways for engaging youth in the implementation of 4IR and maximizing the country's demographic dividend.

Adopting a qualitative research approach, the study utilized desk reviews, 23 Key Informant Interviews (KIIs), four Focus Group Discussions (FGDs), and Small Group Discussions (SGDs) involving policymakers, academics, entrepreneurs, ICT experts, development practitioners, youth leaders, and government officials. Data were analyzed through thematic analysis to identify major patterns, opportunities, and barriers related to youth participation in 4IR.

The findings reveal that 4IR technologies offer considerable prospects for transforming key sectors, including manufacturing, agriculture, healthcare, education, ICT, and financial services. Bangladesh's youth are identified as a critical driver of technological innovation, entrepreneurship, and digital transformation. However, significant challenges persist, including skill mismatches, inadequate digital infrastructure, weak industry-academia collaboration, policy fragmentation, rural-urban disparities, gender inequality, and the risk of automation-induced job displacement. The study emphasizes that the successful utilization of the demographic dividend depends on strengthening digital literacy, STEM education, vocational training, innovation ecosystems, and public-private partnerships.

The study concludes that Bangladesh stands at a critical juncture where strategic investments in human capital, digital infrastructure, and institutional coordination are essential for achieving 4IR readiness. A comprehensive and inclusive policy framework that prioritizes youth empowerment, technological innovation, and workforce preparedness is crucial for transforming the demographic dividend into a sustainable driver of economic growth and national development in the era of the Fourth Industrial Revolution.

CHAPTER 1: INTRODUCTION

1. BACKGROUND

The world is going through an unprecedented change, and technological advancement through the Fourth Industrial Revolution (4IR) is viewed as a great contributor to such phenomenal change. Surely, in the Western world, countries are more advanced and have already transformed their economy and societies by harnessing the benefits of 4IR technology and innovation. 4IR, from a broader context, is mostly concerned with the technical aspects of information, communication, and technologies (ICTs). It is broadly recognized as a transformative era that integrates physical, digital, and biological systems through advanced technologies such as artificial intelligence (AI), the Internet of Things (IoT), robotics, and many more. 4IR, in general, emphasizes the fusion of these domains, leading to unprecedented changes in how people live, work, and interact. It introduces concepts like cyber-physical systems, where physical processes are monitored and controlled by computer-based algorithms, and smart factories that utilize interconnected machines to enhance production efficiency. Thus, worldwide, the rapid pace of innovation in 4IR necessitates a proactive approach to education, policymaking, and infrastructure development to harness its potential fully.

For Bangladesh, 4IR—comparatively a new phenomenon—is expected to open a new avenue by offering opportunities in various social and economic sectors. Bangladesh has a number of national visions and global goals ahead; hence, the country views 4IR as an exciting opportunity to enhance development and ensure quality of life for its citizens. With the gradual adoption of automation, AI, IoT, and other forms of technology, Bangladesh desires to embrace the power of 4IR, mainly considering the huge number of youths.

In Bangladesh, the youth have the power to shape the nation and materialize the dream of a developed country status. In this context, one might argue that to create a strong base for 4IR, the country can utilize its demographic dividend, which is defined as the positive effect resulting from changes in age structure in the overall population (Crespo Cuaresma et al., 2014).¹ Currently, Bangladesh has a higher proportion of the working-age population in relation to the dependent population (Bangladesh Planning Commission, 2020; Bidisha, 2022).² Bangladesh, in fact, has a considerable young population (30 percent of people within the age of 24-30) (Rabab, 2023).³ This young proportion would be of great assistance in realizing Bangladesh's development vision. With ICT remaining the key to reaching this vision, Bangladeshi youth with their innovative minds can become a commendable force in reaching those goals. Around the world, employing advanced technologies, young people have been playing a central role in innovative projects on protecting the environment, improving entrepreneurial activities, combating domestic violence, assisting disabled people, and reducing the communication gap between common people and the government (WEF, 2022; UNDP, 2018).⁴ Hence, harnessing the potential of the youth on the part of the Bangladesh government (BoG) might be imperative in implementing the visions of technological advancement and development goals.

However, over the years, the development of youth in Bangladesh has registered a rather sluggish growth. As per the Bangladesh Labor Force Survey (LFS) 2017⁵, the participation of youth in the labor force has declined quite significantly, which is reflected by a high proportion of youth who are not in employment, education, and training (NEET) (Bangladesh Planning Commission, 2020).⁶ Apart from that, opportunities from the demographic structure of Bangladesh will become limited very soon since, following the year 2030, the growth of working-age people will be slowed down (Bangladesh Planning Commission, 2020).⁷ Therefore, the Bangladesh government needs to contemplate a course of action to find ways to utilize the force of youth in implementing the vision of a developed country in the long run.

1.1 Problem Statement

By and large, Bangladesh wants to adopt digital technologies based on certain parameters of 4IR, such as AI, machine learning, pillars, and a host of others. These envision a data-and information-driven, technology-centric everyday life for people from all across Bangladesh. Nevertheless, the country can utilize its demographic dividend to create a strong base for tech-driven Bangladesh. However, over the years, the development of youth in Bangladesh has registered a rather sluggish growth. Although the previous government has taken a number of initiatives through the “digital Bangladesh” or “smart Bangladesh” ideas,⁸ much has not been worked on its key components, along with the negative aspects of technology. Moreover, the impacts of those programs do not reach much in rural areas. A 2017 survey suggested that the participation of youth in the labor force has declined quite significantly, which is reflected by a high proportion of youth who are not in NEET. Apart from that, opportunities from the demographic structure of Bangladesh will become limited very soon, since after 2030, the growth of working-age people will slow down. Thus, this is high time for Bangladesh to utilize the demographic dividends in all sectors.

It is observed that the Bangladesh government lacks a substantial initiative or strategy that is necessary to build the basic foundation for youth. For starters, there is little to no government support to develop the necessary drivers of 4IR. Secondly, there is little awareness in the policy circle and the general populace regarding 4IR, let alone a skilled workforce. There is also a lack of technical research into the structural limitations faced by Bangladesh in regard to 4IR. There is a visible dearth of literature on the key challenges 4IR Bangladesh might face in its adaptation process. Nevertheless, based on the strategic and policy approaches implemented by other countries (like Bangladesh, India, and Pakistan, for example), there is plenty of room for comparative analysis that may contribute to informative policy papers necessary for future references. Therefore, the GoB needs to contemplate a

course of action to find ways to utilize the force of youth in implementing the 4IR vision.

1.2 Research Objectives and Questions

Against this backdrop, the study intends to address the following research question: What are the probable ways to engage young people in implementing the vision of a technologically advanced nation using the tools of 4IR?

The specific objectives of this study are:

- i) To identify relevant key areas (opportunities) and challenges of youth's involvement *vis-à-vis* the realization of 4IR in Bangladesh; and
- ii) To find ways to overcome the obstacles that emerged from a low IT and knowledge base.

1.3 Rationale

Working on 4IR in both policy making and academic sectors is crucial in the current context, realizing the fact that it has brought disruptive technologies which fundamentally alter various sectors and change the labor skills of a country. The "Competencies 4.0" notion, in particular, which is the key parameter of 4IR, encompasses a set of abilities, knowledge, and attitudes necessary for the people of Bangladesh to excel in this age of rapid technological progress. This notion represents an advancement of previous workforce preparedness frameworks, highlighting flexibility, technical expertise, and the integration of soft skills. Prior research suggests that this idea of 4IR emerged as a reaction to the need for employees to amalgamate digital literacy with conventional problem-solving and leadership competencies (Beck et al., 2021).⁹ Nowadays, for any country, technological literacy is fundamental to Competencies 4.0. The capacity to use sophisticated instruments, such as AI and data analytics, has been extensively regarded as an essential need (Petrillo et al., 2018)¹⁰, and Bangladesh is not exceptional in order to cope with the changing global dynamics.¹¹ To be abreast of

technology advancements, employees must adeptly use digital platforms and engage in ongoing education (Xu et al., 2018).¹² Logical advancements and human-centric competencies like creativity, critical thinking, and emotional intelligence remain essential in changing contexts. Research contends that with the rise of automation, distinctly human qualities become indispensable (World Economic Forum, 2020).¹³

Now, looking at the developed countries (e.g., Japan, Germany, the USA, among others), it is observed that the use of 4IR is extensive, especially in the industrial and education sectors. In these countries, 4IR represents a transformative movement in innovative methodologies, marked by alterations in technology learning processes. Learning-by-doing, which entails acquiring knowledge throughout the production process, becomes more nuanced in businesses characterized by significant systemic complexity, such as the computer sector (German Academy of Science and Engineering/Forschung Union, 2013).¹⁴

As far as Bangladesh is concerned, the government's vision of a 4IR is greatly contingent on its capability to use this information and technology in a prudent way. Therefore, the rationale for doing a study in this particular field is multifold. First and foremost, a significant cohort of the population of Bangladesh is youth who are under 30 years of age. Young people, who are often called the 'youth bulge,' can be a powerful resource for the country. They generally have innovative minds and can help foster development through their active participation by fostering education, training, and technology.

Second, a relatively weak information technology (IT) knowledge base and IT infrastructure might hamper the realization of 4IR in Bangladesh. Bangladesh's performance in the World Bank's Knowledge Economy Index has left a lot to be desired (Bangladesh Planning Commission, 2020).¹⁵ Increasing the skills, creativity, and energy in this sector can help accelerate economic growth and development. Third, the achievement of Bangladesh in the ICT Development Index

(2023) is not quite impressive, with an average score of 61.1 and roughly 38 percent of households having access to the internet (ITU, 2024).¹⁶ All these are significant stumbling blocks in the youth's engagement in materializing 4IR in Bangladesh. Therefore, the current study is an attempt to explore ways to mitigate these issues, which would ultimately pave the way for young people's involvement in every development sector

1.4 Significance

In general, 4IR holds immense significance for the young generation in Bangladesh for a number of reasons. The country's young people are undergoing rapid transformation, particularly in response to technological changes. Now, they can utilize their devices for educational purposes, training, or other beneficial uses. Though the youth can use technology for their own development as well as the country's overall economic growth, they are not contributing significantly because of a lack of skill and preparedness in this particular area. Besides, the implementation of 4IR in the country faces several challenges, including social, economic, and structural impediments.

Like other countries in Bangladesh, there is a general perception with great apprehension that people will lose their jobs due to automation, while the education system struggles to align with emerging technological demands. Limited research and development, weak policy frameworks, and insufficient investment in innovation further hinder progress. Additionally, small and medium enterprises (SMEs) face difficulties in adopting advanced technologies. Cybersecurity threats and data privacy concerns also pose significant risks. For Bangladesh, overcoming these challenges requires appropriate strategic policies, investment in human capital, and strong public-private partnership (PPP) to ensure an inclusive transition to 4IR.

Due to these major hindrances mentioned above, the demographic dividends could not be utilized fully in Bangladesh. Almost half of the young people in the country are unemployed, and most of them are educated. They are not getting vocational or skill-oriented training. Yet, some young people are well-equipped, utilizing the technology of 4IR and earning a handsome amount through freelancing, e-commerce, or working from home. Compared to the previous generation, young people are motivated to learn new knowledge and modern beliefs. Therefore, making a proper platform for them is a need of time.

It cannot be denied that the young generation in Bangladesh can play a crucial role in realizing the 4IR by embracing digital skills, innovation, and entrepreneurship. By acquiring expertise in AI, robotics, blockchain, and IoT, they can drive technological advancements across industries. Startups led by young innovators can create new job opportunities and enhance economic growth. Participation in research, skill-based training, and freelancing in global markets can boost their competitiveness. They can work as a pressure group to update the curriculum as per the needs of 4IR in collaboration with industries and academia. Only a proactive mindset, adaptability, and continuous learning will enable the youth to lead Bangladesh toward a technology-driven, sustainable future in the 4IR.

Since 4IR offers a wide range of digital technologies, it can make a substantial contribution to transforming the economic and industrial sectors of the country. In particular, it can offer ample opportunities for innovation and entrepreneurship, new job creation, and enhanced education and skills. Overall, 4IR can be an important tool for entering the global market and empowering the young generation through technology. It is important to mention that increasing 4IR knowledge can help to reduce poverty, unemployment, and socio-economic problems in Bangladesh. It is observed that after COVID-19, the youth dropped out of school (particularly in rural areas) and engaged in various illegal activities such as drug trafficking, stealing, etc. Creating a job market for these dropout school-going children can be a burden for society in the future if they are not properly utilized.

Therefore, engaging them in productive activities through 4IR is crucial for reducing social unrest. Since youths are the future leaders, focusing on their skills should be one of the key priorities for Bangladesh to make a better and brighter future.

1.5 Scope of the Study

The primary target population for the study is youth; hence, the study limits its scope to this segment. The proposed study attempts to explore ways to get young people involved in activities to realize the vision of 4IR in Bangladesh. Resorting to a qualitative technique, this study has pointed out the associated challenges and opportunities in regard to youth engagement. It has mainly involved concerned officials working in the line ministries, government, NGOs, and young stakeholders from various sectors of Bangladesh to gather information and necessary data. Perhaps the outcomes could have been rigorous if data had been collected on a large scale, especially in rural areas. However, due to time and funding constraints, the data collection has been confined to Dhaka city.

1.6 Organization of the Report

This study is structured to give a detailed and systematic discussion of 4IR, emphasizing its existing challenges and potential pathways for further implementation in various crucial sectors in Bangladesh. For a comprehensive understanding, the study covers a wide range of issues, ranging from challenges to prospects of 4IR in the country.

Chapter One includes the Introduction of the study. It sets the tone of the research by outlining the overall context and significance of 4IR in Bangladesh. It highlights the study's aim, rationale, and the pressing need for 4IR in light of contemporary challenges in the digital age. The section also sets up the research objectives and the key question that guides the overall research.

Following this, **Chapter Two** solely focuses on the Literature Review, along with a conceptual framework based on the existing scholarly works on 4IR. The chapter initially discusses the ideas of 4IR, its genesis, and other critical aspects such as demographic dividends, local and global scenarios of 4IR, and coverage of 4IR technologies in the developing and developed countries. The section critically analyses previous academic works to identify gaps in the literature related to 4IR, especially those aligned to recent developments and emerging concerns, and impediments. By accomplishing that, it analyzes the conceptual framework and sets up a linkage among demographic dividends, youth, and 4IR technology.

Methodology in **Chapter Three** explains the methodological tools and techniques used in this study. In brief, it discusses the overall research design employed for this research. While explaining the research design, it covers sample size and data collection tools, and techniques. It also provides an overview of stakeholders and probable questionnaires. In this chapter, ethical issues are also discussed.

Chapter Four examines the prospects of 4IR in various sectors in Bangladesh. It discusses various initiatives that have been successfully implemented in Bangladesh and showcases its potential to foster the overall development of the country. This analysis also tries to identify the strengths of probable sectors in which 4IR can be implemented on a wider scale in the country in the foreseeable future. After that, the discussion of the challenges of 4IR is highlighted in this section. It considers the observations and insights found from Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs), and based on those findings, it addresses numerous obstacles that hinder the progress of 4IR in Bangladesh. The discussion of this chapter primarily includes an exploration of structural, economic, and social barriers that have collectively sluggish the process of 4IR implementation in the country. By identifying these challenges, this section then provides a clear understanding of the issues that need to be addressed to implement 4IR effectively across the country.

Chapter Five is the last chapter that offers various policy suggestions, taking into account the key challenges of 4IR in Bangladesh. Based on the core findings from KIIs and FGDs conducted among various relevant stakeholders, this section synthesizes their insights into proposed actionable pathways to overcome the identified challenges related to 4IR. Lastly, the chapter has drawn a conclusion by providing a summary of the research for policymakers and stakeholders, offering concrete recommendations for the implementation of 4IR in an effective manner. This section also considers both the major limitations and the critical steps needed to achieve them.

CHAPTER 2: LITERATURE REVIEW AND FRAMING THE IDEAS

By reviewing the literature, this chapter discusses the primary concepts of 4IR, its evaluation, and local and global situations. The chapter denotes that the 4IR signifies a convergence of technologies that obscures the distinctions among the physical, digital, and biological domains. This transition presents considerable difficulties and possibilities for global economies, including Bangladesh, which is charting its industrial growth path. Despite that, the emergence of 4IR presents both problems and revolutionary prospects for developing countries like Bangladesh. The nation now contends with technology obsolescence and structural inefficiencies, yet aggressive initiatives might facilitate its industries in advancing towards the 4IR. Finding out the key research gaps, the chapter delineates that the endeavor from all sides requires smart investments, strong policy frameworks, and a steadfast dedication to innovation. All these points, however, need to be addressed elaborately to grasp the current conditions of 4IR in both global and local spheres.

2.1 4IR: ITS GENESIS

The concept of “4th Industrial Revolution,” known as 4IR for short, is a relatively recent technological approach that has come to prominence over the last 7-10 years. The idea began to gain traction when the book by Schwab (2016), titled *The Fourth Industrial Revolution*, was published in 2016.¹⁷ In his seminal work, Schwab asserted that while many may view what he considered to be a “fourth industrial revolution” as merely a continuation of the third, he thought of it differently due to three crucial reasons—its exponential pace of evolution; the confluence of cutting-edge technologies leading to visible paradigm shifts in multiple aspects of human lives like economic, political, and social values; and the holistic transformation of existing systems people are a part of now. In framing his idea of 4IR, Schwab separates it from its predecessors by highlighting how the “fusion of these technologies and their interaction across the physical, digital, and biological

domains” leads to a much wider impact rather than a simple technological breakthrough. He viewed this change as a global phenomenon that requires ample scrutiny so that every stakeholder from a distinct sector may contribute to realizing the full potential of 4IR.

Before discussing 4IR in detail, a brief discussion about the previous three Industrial Revolutions is needed to understand the overall technological transformation that has taken place over the last several decades. At every stage, human beings were obligated to improve and hone their talents. All revolutions, nonetheless, enhance civilization when they are used correctly. For example, the 1st Industrial Revolution began with the discovery of the steam engine, which allowed mass production in the industrial sector for the very first time. During this period, the world witnessed massive mechanization, production, and growth. The steam engine largely increased productivity beyond what was unimaginable during that period.

The 2nd Industrial Revolution started with the invention of electricity. Once again, the world has witnessed another surge in industrial production capacity due to electricity-based technology. The 3rd Industrial Revolution was pioneered through the invention of digital computers and the internet, which once again provided an unprecedented boost in productivity by making computation and communication smoother. Noticing the trend, the Industrial Revolution always followed the invention of technologies capable of increasing industrial productivity. This revolution was driven by computers, the internet, and other software. Following that thread of reasoning, the world has now just entered the era of 4IR, which was made possible through the invention of cutting-edge technologies like AI, IoT, and blockchain, among others. Unlike the other Industrial Revolutions, the 4IR covers both hardware and software elements along with some form of intelligence; therefore, it has huge implications. These technologies that are associated with 4IR hold immense potential for boosting industrial productivity to a level never imagined before, and the key to 4IR is to be able to achieve that potential through connectivity and data processing.

2.2 4IR: EVOLVING DEFINITIONS

On the whole, 4IR is a contested concept that has been evolving extensively. In the current context, it denotes the emergence of new technologies (e.g., AI, IOT, blockchains, and others) which have massive impacts on the radical change within the existing system. Perhaps, one of the most common definitions of 4IR is articulated by the World Economic Forum (WEF), which defines the term as “a range of new technologies that are fusing the physical, digital and biological worlds, impacting all disciplines, economies and industries, and even challenging ideas about what it means to be human.”¹⁸ Nonetheless, definitions of 4IR vary across scholars, each emphasizing different aspects of its impact and scope. Joanna Kasza (2019)¹⁹, for example, provides a comprehensive perspective by emphasizing not only the technological aspects similar to the notion given by WEF but also the ethical and societal dimensions of 4IR. She analyzed the concept of “cyber-physical systems”, which can reshape human identity and societal frameworks. While her analysis is rich in theoretical implications, it does not delve into the practical applications of these technologies, particularly in industrial or regional contexts. Rashid (2020)²⁰, on the contrary, identifies 4IR as a continuation of the Third Industrial Revolution, driven by innovations like AI, robotics, and quantum computing. He also emphasizes its speed and transformative impact but does not expand on how these changes interact with human lives, a dimension Kasza (2019) and Elayyan (2021)²¹ elaborate on. Shabur and Hridoy (2021)²² approach 4IR from a manufacturing perspective, describing it as a shift toward intelligent systems characterized by real-time communication and smart production. This perspective mainly addresses gaps in earlier definitions by focusing on industry-specific transformations, but it overlooks broader implications for society and governance.

Meanwhile, Xu, David, and Kim (2018)²³ define 4IR as a fusion of digital, physical, and biological technologies, enabling advancements like 3D printing and genetic

engineering. Their focus on innovation breadth contrasts with Shabur and Hridoy's (2021) industrial emphasis, but their analysis is less explicit about the implications for governance and ethics, which Kasza (2019) and Davis (2016)²⁴ address. Khalil and Lokman (2022)²⁵, on the other hand, briefly reference 4IR as a transformation driven by advanced technologies in developed and prosperous nations, but fail to provide a detailed exploration of the concept of 4IR. This gap in depth is compensated for by Alam and Ogawa (2024)²⁶, who emphasize the role of ICT skills in leveraging 4IR for employability and competitiveness, particularly in the Bangladesh context. Islam et al. (2018)²⁷ and Rumi et al. (2020) both focus on physical structures by integrating IoT, automation, and robotics, emphasizing interconnected systems and intelligent networks. While they offer detailed insights into production and manufacturing, they do not address the societal and ethical aspects, which Kasza (2019) and Davis (2016)²⁸ explore extensively in their discussions. Ross and Maynard (2021)²⁹ describe 4IR as an era that merges physical, digital, and biological spheres, shifting from digital automation to intelligent systems. This aligns with broader definitions but does not expand on its regional or societal implications. Elayyan (2021) adds depth by discussing the human-machine interaction enabled by 4IR, along with its potential to improve education, business, and economic opportunities. However, the study could benefit from addressing the challenges or risks associated with these innovations.

Uygun (2021)³⁰ highlights the shift toward autonomous systems and advanced data analytics in industrial processes, focusing narrowly on manufacturing. This leaves gaps in understanding 4IR's societal impacts, which Davis (2016)³¹ partially fills by addressing its influence on governance and societal structures. Davis defines 4IR as an era of cyber-physical systems, emphasizing transformative technologies like blockchain and genome editing. His focus on governance and societal restructuring complements Uygun's narrower industrial scope but does not address technological integration challenges, which others like Shabur and Hridoy (2021) touched upon.

Going a bit advanced, Tang and Shang-su (2017) and Tang and Veelenturf (2019)³² corroborate the conceptualization of 4IR. According to their views, while technologies like AI, IoT, and autonomous vehicles (AVs) are all the key focus of today's discussion of 4IR, what is not truly important is "when each of these technologies will become mainstream, but rather when they will converge and reinforce each other". According to Philbeck and Davis (2019)³³, the concept of 4IR essentially draws upon the past experiences of human society to assess the present and map out a pathway aligning with people's visions for potential futures. Instead of identifying 4IR as a "post-digital revolution," they conclude that it would be more accurate to describe the concept as an "epi-digital revolution" since it builds upon the foundations of the digital revolution. Though the concept itself is not academic in nature, they assess that it is important to properly understand the concept and frame its impacts, especially because the concept is still in its infancy. Going further, they prescribe that a well-defined and framed concept would determine the scope and impact of 4IR in the future. Based on this necessity, there have been some attempts to "define" the concept rather than "conceptualize" it. Lee et al. (2018)³⁴, in other words, define 4IR as a "horizontal expansion of information technology (IT)." Incorporating all the conceptual underpinnings, they determine that 4IR is essentially an upgrade from "simple digitization to innovation based on combinations of technologies". Sekwena (2019)³⁵ defines 4IR as a confluence of the digital, physical, and biological systems through the advancement of technologies.

Regardless of the debates raised by the experts at different times, it is imperative to note that disagreements and skepticism mainly lie over the concept and its key parameters. Notwithstanding that, most of these conceptualizations share a set of common assumptions—that is, 4IR is more than simply a technological revolution. Its scope is not limited to tech-oriented sectors but has a wider impact on a global scale across all aspects of human life. It is a disruptive transformation, be it in a positive or a negative way. Since this concept is a relatively recent development that may swing either way, it is as much of a challenging development as it is one full of promise.

2.3 KEY COMPONENTS OF 4IR

From the above analyses, it can be argued that there is no single definition that fully captures the core components of 4IR in a comprehensive manner. Rather, the ideas of 4IR cover a wide range of parameters. It has primarily brought disruptive technologies, including AI, IoT, blockchain, big data, and automation, fundamentally altering sectors and requiring a change in labor skills. However, Zaman and Islam (2022)³⁶ identify 4IR as a new industrial paradigm centered on “cyber-physical systems”. They mostly highlight the function of IoT, AI, and robotics in creating an “ultra-smart society.” Their definition covers the core technological components of 4IR but lacks depth regarding the societal and ethical parameters, as well as the broader implications of these transformations.

On the whole, 4IR is linked with the notion of ‘competencies 4.0’ encompasses the abilities, knowledge, and attitudes necessary for people to excel in this age of rapid technological progress. The term represents an advancement of previous workforce preparedness frameworks, highlighting flexibility, technical expertise, and the integration of soft skills. Research suggests that the word emerged as a reaction to the 4IRs for employees to amalgamate digital literacy with conventional problem-solving and leadership competencies (Beck et al., 2021).³⁷ The gradual advancements of 4IR profoundly impact manufacturing, logistics, healthcare, and several other areas. Historical evaluations indicate that previous industrial revolutions—marked by mechanization (1st Industrial Revolution), electrification (2nd Industrial Revolution), and digitalization (3rd Industrial Revolution)—set the foundation for the technology-driven environment of the 4 IR (Abdin, n.d.).³⁸

Indeed, 4IR has brought an instrumental enhancement in the traditional structures and simultaneously revival technologies that could be considered ahead of their time (John Andrew van der Poll).³⁹ From the available literature, it appears that the first definition of 4IR was announced in 2011 by the German federal government. Germany Trade and Investment (GTAI) argued that the 4IR was possible due to

technological advancement, and it was narrated as a paradigm shift in comparison to the conventional production process.⁴⁰

Smart and connected manufacturing is defined as 4IR by Sniderman et al in their Deloitte AG report.⁴¹ In a similar way, Brettel et al noted that “Industry 4.0 focuses on the establishment of intelligent products and production processes”.⁴² One of the fundamental features of the 4IR is the factory of the future (FoF), which is popularly known as the ‘smart factory’. Haddara and Elragal (2015) argue that both suppliers and customers need to pay attention to the FoF system.⁴³ There are diverse opinions regarding the 4IR, especially in the industrial sector. Hermann et al, in particular, opine that 4IR is the true mode of digitization for industries. It also introduces innovative ideas and technologies concerning the organization of the value chain, and all necessary characteristics of a smart factory can be addressed by 4IR.⁴⁴ There are industries that are trying to meet the demands of their customers by digitization, which appears to be constantly changing. Heynitz, H.V. et al argued that digitalization in manufacturing is becoming gradually popular and also necessary, as there are numerous benefits to it.⁴⁵ Al Mhqani et al noted that 4IR is there to resolve real-world problems with very little assistance from humans.⁴⁶ The 4IR is defined by the convergence of technologies that obscure the distinctions across physical, digital, and biological domains (Schwab, 2016).⁴⁷

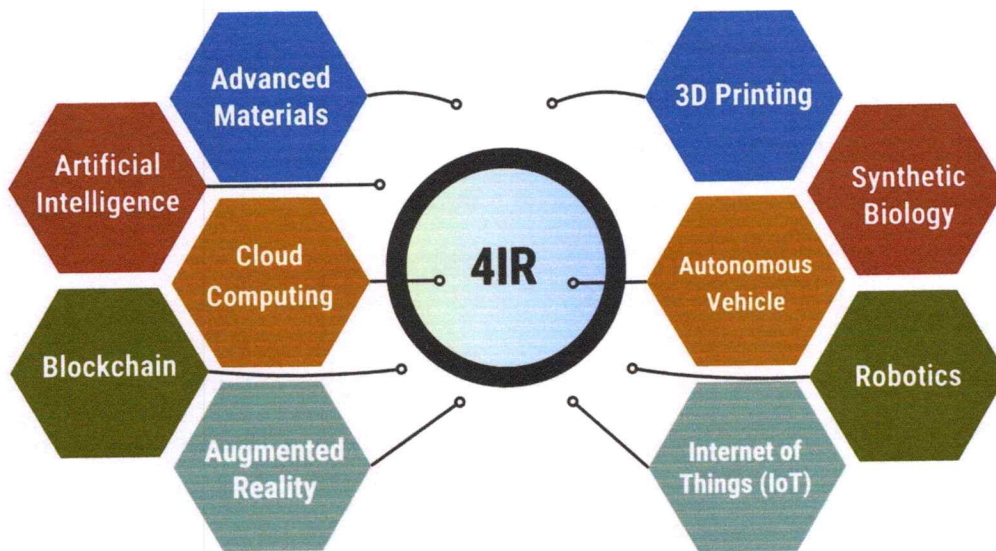


Figure 1: Key Components of 4IR⁴⁸

Considering the above analysis, Figure 1 represents 4IR as a convergence of physical, digital, and biological domains enabled by advanced technologies such as AI, IoT, robotics, and blockchain. It introduces cyber-physical systems that drive innovation across industries and reshape societal, economic, and ethical paradigms. While many scholars address its technological components and transformative potential, gaps remain in regional applications, governance challenges, and the societal impacts of rapid technological adoption.

2.4 4IR IN BANGLADESH: CURRENT STATE

In Bangladesh, 4IR as a concept has been introduced in the development of economies for almost a decade. In many countries, the concept is intertwined with the incorporation of technology into daily business. In the context of Bangladesh, the term has been used in various ways. But in general, it is the progression of technical discoveries, including AI, machine learning, and robotics, which is transitioning into a commercialization phase, whereby these improvements are used in actual production environments. While analyzing 4IR in Bangladesh's context or in general, this tech-driven mechanism in the age of technology is a great race with

AI, 5G robotics, and so forth. As per various studies, 4IR, in the context of Bangladesh, is the technological advancement through navigating various technological tools that are seen as an important step ahead in transforming the country from a heavily digitized one to a developed one in a decade or so (a2i, 2023; Pal and Sarker, 2023).⁴⁹ It has also been an integral segment of Bangladesh's perspective plan for 2021-2041 (ICT Division, Government of Bangladesh).

Based on certain pillars of 4IR mentioned above, Bangladesh wants to envision a data and information-driven, and technology-centric life for people all across the country. Overall, the lives of the people engaging in business, farming, the health sector, education, and other important sectors would be completely transformed digitally. Md. Nasiruddin (2021-2022)⁵⁰ builds on Klaus Schwab's conceptualization of 4IR and is implied in the context of Bangladesh, focusing on its role in fostering knowledge-based societies. While Nasiruddin effectively underscores the macro-level potential of 4IR, the critique lies in the absence of specific applications or implications for Bangladesh, a gap that Zaman and Islam partially address by discussing societal impacts.

Despite various challenges and odds, it needs to be mentioned that Bangladesh has progressed significantly in the digital transformation at the micro level in international trade. According to an estimate of Inspira, the impact of 4IR will be in five major areas in Bangladesh, including agrifood, readymade garment (RMG), textile, furniture, tourism, and hospitality, and these have been widely discussed in Chapter 4. However, currently, numerous sectors function under Industry 3.0, underscoring a technical and operational disparity relative to industrialized economies (Kodama, 2018).⁵¹

2.5 COMPREHENDING THE DEMOGRAPHIC DIVIDEND

For a long time, demographic dividends have been an ideal term for social advancement. Apart from this, the demographic dividend is a crucial factor influencing economic development, especially during revolutionary epochs such as the Industrial Revolution. An analysis of historical antecedents and contemporary applications reveals that optimizing demographic transitions requires extensive strategies in human capital development, healthcare, and economic changes. This signified a phase of demographic change characterized by a decrease in death rates attributed to advancements in healthcare, sanitation, and food security. This established the conditions for decreased fertility rates, eventually leading to a surge in the working-age population and enabling economic reforms (Bloom and Williamson, 2013).⁵²

Nevertheless, the notion of the demographic dividend and its consequences have been crucial for comprehending economic and social changes in both historical and contemporary situations. The demographic dividend denotes the economic development potential resulting from changes in a population's age structure, particularly when the working-age population exceeds the dependent population. This occurs during demographic transitions, often characterized by reduced fertility and death rates (Lee & Mason, 2006).⁵³ The first demographic dividend enhances per capita income when the labor force expands at a rate surpassing that of the dependent population. A secondary dividend occurs when aging populations amass money and assets (Abio et al., 2017).⁵⁴

It is revealed that demographic dividends are interlinked with economic growth. A reduction in dependence ratios may stimulate industrial growth by reallocating resources from consumption to investment in economic and social development. The labor excess during the Industrial Revolution facilitated rapid urbanization and industrial expansion. The migration of rural labor to urban industrial centers

illustrates the demographic dividend's influence on transforming labor markets and capital accumulation (Zhang-yi, 2012).⁵⁵

During industrialization, areas such as East Asia had substantial increases in economic production attributed to their advantageous demographic compositions (Jia, 2014).⁵⁶ Thus, nations must leverage their demographic dividends via education, healthcare, and employment strategies. For example, underutilized young people in areas such as Sub-Saharan Africa are in danger of forfeiting the demographic dividend owing to insufficient investment in human capital (Ssewamala, 2015).⁵⁷ Historical and present analyses indicate that the development of human capital is essential for converting demographic advantages into economic benefits. They highlighted the significance of skill acquisition and educational accessibility (Lutz et al., 2019).⁵⁸ In brief, the demographic dividend depends on how a country utilizes its people to turn them into a skilled force for the sake of the overall development of the country.

2.6 DEMOGRAPHIC DIVIDENDS AND BANGLADESH: BIRD'S EYE VIEW

From the above discussion on demographic dividends in general, the question that arises is: Why should demographic dividends be discussed separately in the context of Bangladesh, and why does it need to be given utmost importance? It is worth mentioning that, currently, Bangladesh is enjoying the dividends of its demography because of the change in demographic structure, including the presence of a large number of youths. Over time, this demographic transition has taken place due to low fertility and mortality in Bangladesh. Following the 2022 Census data, it is noted that, with its large and youthful population, the country holds significant potential to capitalize on its demographic dividends. It is a positive demographic trend that the proportion of the country's working-age people is 66 percent, which was 61 percent in the 2011 census data.⁵⁹ This means that the percentage of dependent people has decreased considerably. This critical period, characterized by

a high proportion of working-age individuals, presents opportunities for economic growth and development, particularly in the context of 4IR.

Nevertheless, it needs to be considered that this window of demographic opportunity will be over nearly in 2020, and after the proportion of elderly people will increase. Thus, this is high time to focus more on the youth and find better opportunities for them. In terms of population quantity, a quality population is pertinent to ensure a country's economic prosperity. To accomplish this goal, it is high time to focus on policy planning and proper resource allocation in the country.

At present, the preparation for utilizing the demographic dividends is not up to the mark. Although it is a great opportunity for once in a lifetime to reap economic growth, Bangladesh has not yet prepared much. Rather, the effective utilization of this opportunity is hindered by systemic challenges, as highlighted by various authors. Shabur and Hridoy (2022)⁶⁰, for example, describe Bangladesh's demographic dividend as underutilized, emphasizing the necessity for reform to align with the technological demands of 4IR. They focus on the potential of technological upskilling to leverage the young workforce. However, they fail to provide specific policy recommendations for Bangladesh. Rashid (2022)⁶¹ builds on this by identifying the 4IR initiative as a means to enhance digital literacy and capitalize on the demographic dividend, yet this work does not delve into vocational or sector-specific training.

In this regard, Zaman and Islam (2022)⁶² take a forward-looking approach, advocating for specialized education and digital training to prepare the youth for technological innovation. Their analysis provides valuable insights into skill development but overlooks the role of existing industries in absorbing this skilled labor force. Islam et al. (2018)⁶³, similarly, stress the modernization of the education system to focus on technical and vocational skills, providing a foundation for 4IR integration. However, both studies lack detailed examples of successful implementation or global comparisons.

Rumi et al. (2020)⁶⁴, on the other hand, identify the absence of targeted policies as a major barrier to utilizing Bangladesh's youthful workforce. Their analysis highlights the untapped potential of this demographic dividend but stops short of offering concrete strategies to address this gap. Nasiruddin (2021-2022) introduces the role of libraries in enhancing digital literacy, particularly among the youth. This unique perspective identifies an often-overlooked resource but fails to connect these efforts with broader economic or technological initiatives. Elayyan (2021) and Khalil and Lokman (2022)⁶⁵ discuss the critical need for education and skill development to harness Bangladesh's demographic dividend, emphasizing that this window of opportunity will close by 2041. While their focus on education is essential, they neglect other enablers such as economic diversification and technological adoption. Alam and Ogawa (2024) also highlight the underutilization of the youthful labor force, attributing it to gaps in ICT education and employability skills. Their work provides a more holistic view but could benefit from examples of successful global models that Bangladesh could emulate.

Islam et al. (2022) link the demographic dividend to achieving Sustainable Development Goals (SDGs) through ICT and digital education. However, they fail to provide specific examples of how young people can be integrated into technology-driven sectors. Similarly, Hossain (2024) emphasizes the need for vocational training to integrate 4IR technologies into education and employment but underexplores how these industries could absorb Bangladesh's youthful workforce.

Globally, Xu, David, and Kim (2018) suggest that nations with young populations can harness their demographic dividend by transitioning from manual labor to skilled, knowledge-based professions. This observation aligns with the challenges in Bangladesh but lacks a specific roadmap for such a transformation. Abusaleh (2017) and Roy and Kayesh (2016) focus on the broader implications of demographic dividends, discussing the importance of education and job creation. However, their analyses need to integrate the role of technological advancements, particularly 4IR, in maximizing the benefits of a youthful workforce. Ross and

Maynard (2021) imply that the young population can play a pivotal role in integrating 4IR innovations if education and infrastructure gaps are addressed, a perspective that complements the challenges identified in Bangladesh. Meanwhile, Uygun (2021)⁶⁶ emphasizes the necessity of skilled labor for 4IR but does not explore the implications of demographic dividends, leaving a critical connection unaddressed.

2.7 DEMOGRAPHIC DIVIDENDS AND 4IR: CURRENT SITUATION IN THE GLOBAL SOUTH

In the global South, 4IR offers immense potential despite having a lot of crucial challenges. While it has a far-reaching impact on various sectors, 4IR also poses its own set of unique challenges in various aspects of human life in these countries. Ketchiwou and Ngulube (2024)⁶⁷ point out that most developing countries are still unprepared to adapt to the disruptive transformations brought about by 4IR. In the case of past industrial revolutions, developing countries were not given a level playing field. Using the global North as an example, the authors highlight how developed countries are flourishing their own economies and expanding markets in this region while utilizing the benefits of 4IR. Some developed nations, such as Germany, Japan, and the United Kingdom (UK), are at the forefront of 4IR, implementing initiatives like Industry 4.0 and Society 5.0 that integrate advanced technologies across industries and societies.

On a similar note, like other authors, Adhikari agrees that 4IR is still in its infancy. Therefore, the Least Developed Countries (LDCs) or the countries of the global South were unable to reap the benefits of the previous three industrial revolutions in time. But now is the optimal time for these countries to join in this movement. Research conducted by the United Nations Development Program (UNDP) in collaboration with the Economist Intelligence Unit (EIU)⁶⁸ in the Asia-Pacific region has unearthed a more comprehensive set of challenges due to 4IR. According to their Report, progress on at least 9 sustainable development goals (SDGs) could

be directly affected by 4IR, leading the emergent middle class of Asia to slide back into poverty *en masse*.

Ayentimi (2020)⁶⁹ noted that developing countries face their fair share of challenges when it comes to the question of the implementation of 4IR. According to him, 4IR can not only lead to diversification of the economy, it also lead to economic modernization by digitizing agriculture and industry and promoting innovation. However, the most common set of challenges most developing countries face is the lack of a necessary workforce, capabilities, and skill sets, as well as infrastructure, which the developed countries have in abundance. What most of them do have, however, is a demographic dividend of a youthful workforce, whereas most developed countries are struggling with an aging population. The resource could be effectively utilized if the youth were to be trained as highly skilled workers in the global South.

The research by the Tony Blair Institute looks into the challenges faced by African countries in their attempts to adapt to 4IR. According to their Report, the incorporation of automatons in the manufacturing sector is posing a threat to labor and risking “premature deindustrialization” (Akileswaran and Hutchinson, 2019).⁷⁰ Furthermore, this stabilizing effect may have a severe impact on the West by exacerbating the migration crisis. Unless Africa can safely navigate through the adaptation process by minimizing the repercussions, it may lead to wide-scale instability in the region in the near future.

Adhikari (2020),⁷¹ however, offers a way to mitigate that problem. According to him, unlike the previous industrial revolutions, there are ample benefits that 4IR can offer to the LDCs so long as the three ‘A’s—Accessibility, Affordability, and Application—can be ensured. He stresses that LDCS must diversify its resources by pooling from both public and private sources by ensuring necessary infrastructural development, focusing on science, technology, engineering, and mathematics (STEM) education to facilitate skill development and promote research, development, and innovation to shape their own system. Most

importantly, he highlights the need for establishing a sustainable implementation and monitoring mechanism in place to avail the full benefits and potential of 4IR.

Based on the above discussion, it appears that owing to the historical dependency on developed states, most developing countries face similar challenges in adapting to the 4IR due to a lack of resources, infrastructure, belated industrialization, and a low-skilled workforce. Nevertheless, the advancement of 4IR is still in progress, which makes now the ripe time for such countries to begin developing themselves in accordance with suitable adaptation strategies to become a part of the 4IR, unlike the previous three industrial revolutions, where the developing countries were left behind. Most developing countries share an advantage over their developed counterparts due to their youthful demographic dividend. This advantage, if utilized properly, could smooth the process of integration into the world of 4IR.

2.7.1. 4IR: Good Examples and Adaptation Strategies of Some Asian Countries

Some countries in Asia, such as Japan, Hong Kong, South Korea, Taiwan, and Singapore, popularly known as the “economic miracle”, have brought huge economic transformation by using demographic dividends.⁷² Singapore, for example, has launched Smart Nation Singapore and Skills Future initiatives to transform the education system, which would lead to the creation of employable citizens in a 4IR-centric economy (Gleason 2018).⁷³

The Japanese government, for instance, introduced the term “society 5.0” to integrate social problem-solving with the commercial advancements of Industry 4.0. This system comprises sensors, actuators, and multilayered feedback loops, including edge computing. Research has been undertaken on sensors, actuators, and edge computing to examine the novel paradigm of technological learning for Society 5.0 (Christensen, 2003).⁷⁴ A proactive learning approach is evident in both sensors and actuators, and a strategic alignment between business strategy and technology is essential for success. Learning-by-porting is the prevailing approach

for edge solutions, and the advancement of Society 5.0 adheres to learning-by-(multilayered, multiple)-porting. Impact hubs such as Sustain Launch Labs have also organized hackathons at different universities, providing access to unique ideas and meaningful solutions (Kodama, 2014).⁷⁵

Meanwhile, Malaysia has its own “National 4IR Policy.” The policy highlights the necessity of promoting a culture of innovation and creativity in Malaysian society and seeks to enhance Malaysia’s productivity across all sectors. The policy document also emphasizes the “ethical use of 4IR technologies” in its development process. The objective of Malaysia’s National 4IR policy is to first ensure a better quality of life and overall social development, promote competitive business and innovation, and lastly, build a technologically capable and efficient government that would provide modernized public services. To that end, the strategy framework prioritizes equipping existing and future workforces with necessary 4IR skills, incentivizing the industries for upskilling and reskilling the workforce, promoting innovation by encouraging 4IR-exposure-from-school-level, introducing 4IR-related courses in higher education and vocational education, and ensuring the necessary policy implementation for the technological advancement and infrastructure required to put the strategy into practice (National 4IR Policy 2021).⁷⁶

In contrast, the use of 4IR in Indonesia, the Philippines, and Vietnam is rather bleak, and at least 60 percent of salaried workers hold vulnerable positions that might be put at risk due to the use of automation. Even though the use of automated technology would boost efficiency, in economies that are over-reliant on low-skilled labor, the development of 4IR in these countries may risk higher rates of unemployment. The gendered dimension of unemployment is caused by technological advancement, citing that men tend to gain one job for every three jobs lost, whereas women tend to gain one for every five jobs lost. Another concern is the “premature deindustrialization” of developing economies, especially the labor-intensive manufacturing economies, which might do more harm than good. The key point to be noted is that some Asian countries (e.g., Malaysia, Vietnam,

Bangladesh, and Thailand) are all highly dependent on the manufacturing sector, which might be at risk due to the use of AI-based automated technology (UN, 2018).⁷⁷

The Association of Southeast Asian Nations, commonly known as ASEAN, has employed its own strategic framework to help the ASEAN members adapt to 4IR (ASEAN, 2021).⁷⁸ In its consolidated strategic framework, the organization has prioritized the advancement of technological governance and cybersecurity, the digital economy, and the digital transformation of society. The strategic framework also states that ASEAN's 4IR adaptation strategies are based on a community-wide approach to ensure equal development of all members.

Among South Asian countries, India has made crucial strides in receiving 4IR and advancing its technological innovation. At present, India is known as a leader in the global IT and software sector, in which it has taken several tech startups and has a thriving digital ecosystem. The country has taken several ventures like "Digital India" or "Startup India" to accelerate its economic growth. As a result of taking extensive initiatives in this sector, India now has a large skilled workforce and is enjoying the growth of the technological sector. Despite its significant success, India has been struggling to fix certain social and structural

On the contrary, Asghar et al. (2020)⁷⁹ discuss the case study of Pakistan as an example of a developing country employing a 4IR adaptation strategy. Despite being an agro-based economy, Pakistan is starting to comprehend the necessity of developing a robust technological infrastructure. Pakistan's Higher Education Commission (HEC) is currently promoting the establishment of research centers on AI, robotics and automation, data analytics and cloud computing, and cybersecurity. One such research center is the *Presidential Initiative for Artificial Intelligence & Computing*. Pakistan has also set up a national technology fund named *Ignite*, which promotes and funds startups that work with 4IR technologies. This initiative not only seeks to develop a skilled workforce but also promotes innovation. Pakistan has also employed a cybersecurity initiative named

COMCERT, which aims to strengthen cybersecurity by providing services like warning, incident handling and analysis, response, support and coordination, capacity building, and awareness, among others.

Bangladesh has progressed well, especially in the use of 4IR in the large economy and financial sector. The country is growing its tech industries. However, in sharp contrast with other Asian countries (e.g., India and Pakistan), Bangladesh has no such notable initiatives on 4IR or a strategic framework in place. According to Islam et al. (2018)⁸⁰, five problems are hindering Bangladesh's adaptation process to 4IR—government support, lack of knowledge, poor infrastructure, availability of cheap labor, and expensive installation of technologies.

It is a great hope that the developing economies have already begun to explore the domain of 4IR by laying the preparatory groundwork that may help overcome the challenges and operational limitations they face in adapting to 4IR. By formulating policies that encourage research, awareness, innovation, and skill development, some countries have set the foundation that would generate a highly skilled workforce in the near future. Some of them have also charted out dedicated national strategic frameworks to ensure the necessary government support for such an undertaking.

2.8 FINDING OUT KEY RESEARCH GAPS: GLOBAL AND LOCAL CONTRAST

4IR is an emerging sector in Bangladesh; hence, the experience of utilizing its tools in various sectors is quite new. Currently, Bangladesh is facing significant challenges, including inadequate infrastructure, a lack of skilled labor, and insufficient policy frameworks, among others. Considering various aspects discussed above, a number of authors critically identify the loopholes and major gaps in lagging behind in 4IR implementation in Bangladesh. Like many, Zaman and Islam (2022)⁸¹ highlight the issues of the country's reliance on low-skilled labor and limited technological adoption. While they provide a strong overview of

the country's lagging status, their analysis lacks actionable strategies to address these issues, leaving a gap that Islam et al. (2018)⁸² partially addressed by proposing investments in infrastructure and skill development as priority areas. In this aspect, they argue that Bangladesh is in the early stages of 4IR adoption due to high technology costs, poor infrastructure, and a lack of skilled labor. While their investment recommendations are relevant, the analysis does not discuss the role of specific industries in driving 4IR adoption.

In addition to that, Rumi et al. (2020)⁸³ in their study have attempted to fill this gap by identifying digital transformation as a promising area, though they similarly failed to outline how these transformations can address regional or rural disparities. On the other side, Alam and Ogawa (2024)⁸⁴ provide a comprehensive view of 4IR's evolution globally, noting its impact on economies, education, and industries. They highlight specific challenges for Bangladesh, such as inadequate ICT education and outdated equipment in universities. While they suggest fostering industry-academia collaboration to address these gaps, their analysis lacks insight into how this collaboration could translate into tangible outcomes, an issue partly explored by Ross and Maynard (2021)⁸⁵, who emphasize the need for foundational smart infrastructure as a prerequisite for progress.

Globally, 4IR has been viewed as a force disrupting industries and creating new markets, and this has been eloquently articulated by Xu, David, and Kim (2018).⁸⁶ For Bangladesh, they note the limited integration of high-tech industries and insufficient investment in knowledge-based sectors. Their work provides valuable global comparisons but lacks context-specific solutions for Bangladesh, a gap that Elayyan (2021)⁸⁷ attempts to bridge by emphasizing educational integration and early adoption phases of technologies like AI and blockchain. However, Elayyan's analysis lacks a detailed exploration of the infrastructural and industrial transformations needed for Bangladesh to advance.

While identifying a distinct angle, such as broadband infrastructure and data security, Uygun (2021)⁸⁸ mentioned global readiness for 4IR, discussing

advancements like smart factories and adaptive logistics. These global insights are relevant for Bangladesh, where technological infrastructure and skill development remain key challenges. However, Uygun does not address how developing nations like Bangladesh could adopt global best practices, a gap that Khalil and Lokman (2022)⁸⁹ touch on by emphasizing the potential of youth and rural development in leveraging 4IR. Despite this, their analysis lacks specific strategies for integrating 4IR technologies into local industries.

Abusaleh (2017)⁹⁰ and Roy and Kayesh (2016)⁹¹ in their paper, furthermore, discuss 4IR, highlighting fundamental challenges in Bangladesh. They initially highlight some key research gaps in infrastructure and skill development. However, their work fails to connect these challenges to 4IR technologies, leaving an incomplete picture of how these impediments could be addressed in a global context. Islam and Zaman (2022)⁹² address this by linking global 4IR advancements to Sustainable Development Goals (SDGs) but miss the opportunity to compare Bangladesh's progress with its regional peers.

Hossain (2024)⁹³ provides an optimistic outlook by noting efforts to build high-tech parks and promote ICT in Bangladesh. However, his analysis could benefit from comparative insights into how similar countries have tackled 4IR challenges, a perspective partially provided by Shabur and Hridoy (2022)⁹⁴, who highlight the RMG and IT sectors as potential drivers for 4IR in Bangladesh despite systemic challenges. Nasiruddin (2021-2022)⁹⁵, on the contrary, emphasizes global successes in revolutionizing industries through 4IR but critically analyzes Bangladesh's struggle with infrastructure, skills development, and awareness, particularly among library professionals. While this focus is narrow, it highlights a broader issue of limited digital literacy, which could hinder 4IR adoption across sectors.

This critical analysis shows that despite possible benefits, Bangladesh has been facing challenges in managing resource allocation and population expansion. These constraints, as stated by Desai (2010),⁹⁶ underscore the need for specific policy

measures to properly capitalize on demographic prospects. Ahmed et al (2016)⁹⁷ said that countries now undergoing transitions (like Bangladesh) should learn from historical industrialization, highlighting the need for proactive labor market strategies and infrastructure investments to support demographic changes.

In summary, from the above discussion, it is apparent that due to a lack of inclusive discussion, there remain significant gaps in the literature and academic arena about 4IR. Although a number of studies highlight the 4IR and its key challenges, very few studies provide detailed, actionable policies for integrating youth into specific 4IR sectors such as AI, industry, or advanced manufacturing in Bangladesh. Additionally, the role of private sector partnerships and global benchmarks in achieving these goals is underexplored. To fully realize the benefits of this linkage, Bangladesh must adopt a comprehensive approach that includes policy innovation, economic diversification, and targeted investments in youth-centric 4IR initiatives. By addressing these gaps, the report, thus, is an attempt to showcase that Bangladesh can not only harness its demographic dividend but also establish itself as a leader in 4IR-driven development. Youth, as the centerpiece of this transformation, represents the country's greatest asset, capable of bridging the gap between technological potential and economic reality.

2.9 FRAMING CONCEPTS AND IDEAS: LINKING YOUTH, 4IR, AND DEMOGRAPHIC DIVIDENDS

4IR, youth participation, and the demographic dividend present a synergistic opportunity for Bangladesh to achieve economic transformation and sustainable development. With a youthful population at the heart of its demographic dividend, the country can leverage this demographic advantage by aligning youth skills with the demands of 4IR technologies. The term 'youth', as the centerpiece of positive transformation, represents the country's greatest asset, capable of bridging the gap between technological potential and economic reality.

Various scholars highlight this linkage by identifying potential in their analyses that reveal areas for further exploration. For instance, Zaman and Islam (2022)⁹⁸ emphasize the critical role of 4IR technologies in maximizing Bangladesh's demographic dividend through youth development. They argue that aligning education and training with 4IR demands is key to preparing the workforce for a technology-driven future. Alam and Ogawa (2024)⁹⁹, stress the need for ICT-focused curricula and practical skill development programs to bridge the gap between educational outcomes and labor market needs. They also addressed how industries can absorb this newly skilled workforce.

Davis (2016)¹⁰⁰ underlines the importance of collective decision-making in ensuring equitable tech adoption, highlighting the need for policies that foster youth entrepreneurship in tech sectors. The study of Ross and Maynard (2021)¹⁰¹ explicitly connects 4IR to Bangladesh's demographic dividend, leaving the practical implications for the country unaddressed. They build on this by discussing how youth can learn and implement disruptive technologies like AI and IoT, offering examples such as mobile apps and smart city initiatives, though they stop short of proposing specific policies tailored to Bangladesh. Islam et al. (2022)¹⁰² link ICT training and e-governance initiatives to youth participation in 4IR sectors while addressing SDG goals.

On the contrary, Rumi et al. (2020)¹⁰³ address specific policies or sectors, such as the linkage between renewable energy access and AI. They advocate investments in STEM education, vocational training, and entrepreneurship to empower youth for the 4IR. Nasiruddin (2021-2022)¹⁰⁴ introduces a novel perspective by emphasizing libraries and digital tools as a means of preparing youth for 4IR challenges. This approach is echoed by Hossain (2024)¹⁰⁵, who emphasizes depth regarding how youth entrepreneurship or employment in 4IR sectors could directly maximize the demographic dividend. For this, they emphasize skill training and entrepreneurial ventures and offer a few actionable policies to connect youth to specific 4IR-driven sectors. Uygun (2021) highlights the importance of lifelong learning in aligning youth skills with 4IR demands. While Uygun underscores the

importance of continual upskilling, similarly, Khalil and Lokman (2022)¹⁰⁶ recognize the youth as drivers of the 4IR era through technology-focused education and entrepreneurship.

Some earlier works, such as Abusaleh (2017)¹⁰⁷ and Roy and Kayesh (2016)¹⁰⁸, focus on the importance of job-oriented education and vocational training. Besides, there is a role of 4IR technologies, such as automation and AI, in enhancing youth employability and productivity since the youth can adapt to future labor market demands. From empirical research, Nghihepavali and Chata (2024)¹⁰⁹ noted that there is a strong correlation between 4IR and social development parameters such as SDGs. They further mentioned that there is a strong and positive connection between 4IR on SDGs, particularly on the aspects of demographic dividends, including youth empowerment and reducing wealth gaps. Klaus Schwab, the Founder and Executive Chairman of the World Economic Forum, identified four areas where the youth can focus to have a profound impact on the 4IR. The areas are workforce readiness skills, entrepreneurship skills, soft skills, and technical skills.¹¹⁰

In brief, there is a huge possibility that the 4IR will open an avenue of opportunity for the young generation in Bangladesh. With the increasing embeddedness of digital technology in many works, it is assumed that youths who are digital natives in nature will get ample opportunities for themselves in the 4IR.¹¹¹ Thus, the linkage between 4IR and youth participation offers significant positive implications for the country. By equipping its youthful population with the skills required for 4IR technologies, it can drive economic growth, foster innovation, and maximize its demographic dividend. Strategic investments in STEM education, ICT training, and entrepreneurship can position youth as the drivers of a tech-enabled economy. Moreover, certain initiatives like "Smart Bangladesh" highlight the potential for public-private collaboration in upskilling youth and creating pathways for their participation in technology-driven sectors.

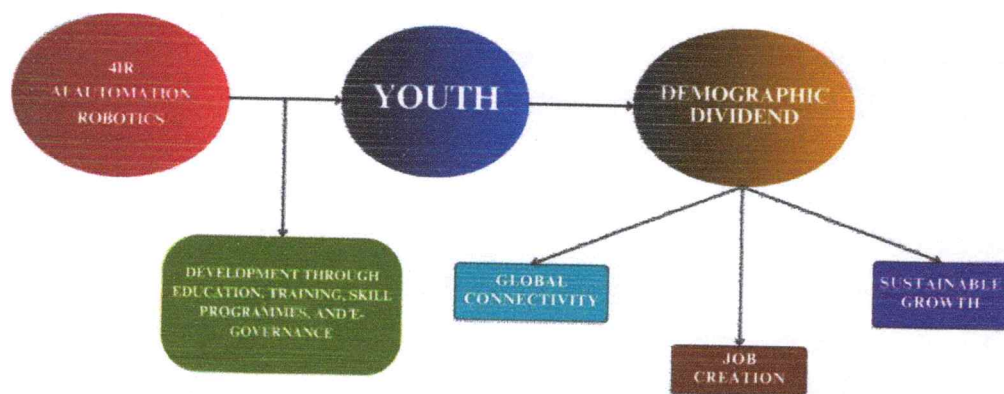


Figure 2. Linkage Between 4IR, Youth, and Demographic Dividend¹¹²

The above diagram (Figure 2) shows 4IR in the context of Bangladesh. 4IR denotes all sorts of digital infrastructure like AI, automation, robotics, blockchain, IoT, cloud computing, 3D printing, and other technological advancement tools. The youth of Bangladesh who is enthusiastic, innovative, and energetic have the potential to harness this area by participating in various “Tech-driven workforce”. Due to the rise of 4G networks, the use of mobile phones and internet access has risen sharply among this cohort, and they can emerge as crucial “entrepreneurs”. They can create more demands and opportunities in the service sectors, especially in banking (mobile money), education (online platform), and health care (telemedicine). The use of AI, robotics, and IoT in the textile, garments, and agriculture sectors is gradually showing more demand and more opportunities for Bangladesh. Consequently, the youth will assist in engaging in “global connectivity”, “global market”, and overall “sustainable growth” of the country.

Now, it can further be argued that the concepts of demographic dividends, youth, and 4IR are closely associated, and detailed, actionable policies for integrating youth into specific 4IR sectors (such as industry or advanced manufacturing, etc.) are required. Moreover, the role of private sector collaboration and global benchmarks in achieving these goals is needed. To fully reap the dividends of this linkage, Bangladesh must adopt a comprehensive approach that includes policy innovation, economic diversification, and targeted investments in youth-centric 4IR initiatives. By addressing these linkages, Bangladesh will be able to harness its demographic dividends and establish itself as a leader in 4IR-centric development.

CHAPTER 3: METHODOLOGICAL OVERVIEW

The chapter deals with the methodology adopted by the current study on 4IR. As it is recalled, the main objective of this study is to find ways to get the young people of Bangladesh involved in the implementation of 4IR. At the same time, it would attempt to find out the probable challenges and prospects or opportunities in this regard. The nature of these objectives demands a qualitative method. This research does not find out the impact of any phenomenon, nor does it compare the impact of a change with a control group. It also does not test or validate any hypotheses based on numeric data points. As such, the tool of the qualitative method is appropriate here. Therefore, this chapter is an attempt to discuss the research design employed in this study. The chapter also covers a detailed discussion on sample size, data collection method, types of questions, as well as ethical issues.

3. APPROACH

3.1 Qualitative Research

Choosing the correct methodology is the key to the success of any research. Research methodology steers a researcher to rationally gather and analyze data from the study area (Gregory, 2009).¹¹³ In social science, a researcher has to choose between qualitative or quantitative methods or both (mixed method). However, there always exists a debate on the suitability or appropriateness of the methods because the correct method leads to the reliability of the findings of any study.

A qualitative type of research is appropriate for this study since it mainly involves the understanding of a phenomenon by obtaining non-numeric data or information (Oranga and Matere, 2023).¹¹⁴ According to Fossey et al. (2002)¹¹⁵, qualitative research engages with issues in regard to “an understanding of the meaning and experience dimensions of humans’ lives and social worlds”. Such type of research is carried out in order to get a deeper understanding of “people’s experiences,

behavior, beliefs, attitude and motivation” (Oranga and Matere, 2023).¹¹⁶ Qualitative research attempts to take on issues and get a clear and well-rounded meaning of the real-life problem without really resorting to quantitative information (Moser and Korsrjens, 2017).¹¹⁷ In fact, qualitative research takes up questions concerning “why” and “how” questions rather than “how many” or “how much” (Moser and Korsrjens, 2017).¹¹⁸ As the research objectives of this study mostly deal with why and what aspects instead of quantifying anything, qualitative research does fit well here.

Besides, a qualitative research design is adopted for this study owing to a number of reasons. First, to address the why question, this study needs to find out the experience of the individuals about the phenomenon (Winchester and Rofo, 2010).¹¹⁹ It has also been acknowledged that such living experiences are also influenced by a web of processes, social, economic, cultural, and political (Limb and Dwyer, 2001).¹²⁰ Second, the current study is exploratory in nature as it attempts to get insights into the complex issue of 4IR implementation and the role of youth in the context of Bangladesh. Hence, qualitative design is an appropriate fit here, as noted by Flick (2009)¹²¹.

3.1.1 Research Design

The research design of the study relies on a logical structure of systematic inquiry characterized by precise steps of data collection (Parsons and Knight, 2005). Yin (2016), in this aspect, clearly demonstrates that research design needs to be intertwined with the research questions, research objectives, and empirical data. Likewise, a systematic process has been followed for the entire research report (see Figure 3), and various research tools have been employed to gather accurate data.

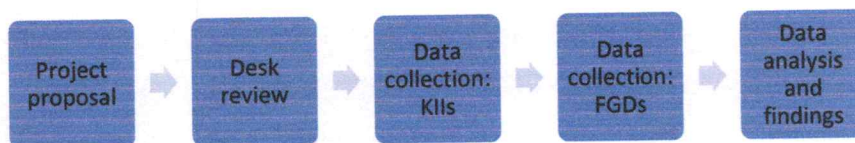


Figure 3: Key Steps of Accomplishing the Research Report¹²²

Primarily, qualitative research follows five research designs, namely, grounded theory, ethnography, narrative study, case study, and phenomenological study (Oranga and Matere, 2023).¹²³ Grounded theory generates or develops theory based on the interpretation of the data obtained by the study. This approach enables us to build a theory to explain the issue(s) at hand (Foley and Timonen, 2015; Corner et al., 2019).¹²⁴ Ethnographic research involves the analysis and interpretation of the data obtained from researchers' living experiences with subjects from different societies and cultures. Here, the researcher attempts to get deeply involved with subjects to get a deeper understanding of particular phenomena (Grossoehme, 2014).¹²⁵ Case study research, as the name itself suggests, is a detailed and thorough inquiry into the development of a solitary case (Oranga and Matere, 2023).¹²⁶ Particularly, a case study assists researchers in investigating various social issues (Zamawe, 2015)¹²⁷.

The phenomenological study mainly focuses on the interpretation and experience of different subjects on the phenomena (Oranga and Matere, 2023).¹²⁸ Using the subjects' viewpoint, this study deals with their experiences on a particular issue. As far as narrative research is concerned, it goes beyond asking questions from a structured questionnaire; rather, this type of study delves into the researchers' understanding of the experience of only a few subjects about any issue (Oranga and Matere, 2023).¹²⁹

As for methodology, the current study adopts phenomenological research. Such research “describes the common meaning for several individuals of their lived experiences of a concept or a phenomenon” (Creswell & Poth, 2018). For this research, a phenomenological study method is followed since it seems a highly appropriate approach while discussing 4IR in Bangladesh. Since this approach primarily focuses on the lived experiences and social impacts of both individuals and communities, this method does fit well to understand how people at various stages (such as students, young entrepreneurs, and policymakers) are experiencing and receiving this new technological orientation and changes. In this research, the interviewees narrated their experiences and were allowed to share their ideas about the issue. This approach also allows the researchers to capture the lived experiences of individuals, providing rich insight as to how they are struggling to cope with these changes. 4IR has an impact on various segments of society in a distinct way. For example, the impact is largely different in rural vs urban areas, and skilled vs unskilled communities. Therefore, a phenomenological study allows different groups to experience differently depending on their cultural backgrounds, educational levels, age groups, etc.

The current research also follows an interpretivist paradigm as it attempts to understand different ways stated by different interviewees on how to maximize the potential of the Bangladeshi youth to implement 4IR in the country. The authors have also tried to find out from these interviews what the possible obstacles and opportunities are. In the same vein, the ontological stance is relativism, which is regarded as the belief in multiple realities.

The epistemological position of the study is constructivism. According to this notion, the world is independent of the minds of human beings, but different people tend to construct their understanding and knowledge about reality by means of experiences (Creswell & Poth, 2018).¹³⁰ The current study interviews several stakeholders to provide their experience and share their ideas and opinions on the phenomenon of 4IR and the engagement of Bangladeshi youth.

As a part of the qualitative research technique, the study has conducted an intensive desk review. Here, relevant literature has been surveyed to get a deep understanding of 4IR, its demographic dividend, and the current state of Bangladeshi youth. The literature has included articles, government reports, studies by the private sector, United Nations (UN) bodies, newspaper reports, etc. The review has further assisted in getting an idea about the requirement for data. The study requires the participation of concerned personnel from relevant government agencies and non-government bodies to obtain necessary data and information. The desk review has helped find the appropriate persons and non-government organizations (NGOs) to gather data.

3.1.2 Population and Sample Selection

The participants for this research were selected through purposive sampling. Some academics from the universities who are experts on the issue, relevant government officials from line ministries, young entrepreneurs, and officials and resource persons from youth training institutions. In total, 10 participants were interviewed, with each interview lasting between 30 to 40 minutes. A statement explaining the study was emailed to them beforehand, while necessary consents were obtained from the participants prior to the interviews. Hereafter, the participants were identified by their pseudonyms A, B, C, and D.

Participants	Gender	Current Employment	Years of Experience
A			
B			
C			
D			

Table 1. A Brief Profile of the Research Participants¹³¹

3.1.3 Data Collection Instruments: KIIs and FGDs

In order to collect the relevant data, the study adopted three methods, namely, desk review (as discussed already), KIIs, FGDs, and a small group discussion (SDG). In total, 23 KIIs across various sectors (See Annex 2) are interviewed to gather distinct opinions. For the KIIs, the study project selected relevant people from academia, government, youth leaders, youth entrepreneurs, and resource personnel from vocational training institutions. The young entrepreneurs are specially chosen to understand what they are aware of 4IR and are practicing its different tools.

From the academic discussion outlined in the previous chapters, it is revealed that many young people lack great skills due to the absence of hands-on experience. To fill in this gap, many institutions provide the youth with opportunities to develop their skills. As a result, this study has selected a number of organizations working with the youth cohort to secure better opportunities abroad for career growth. Many young professionals (YPs) from this platform have secured jobs in NGOs, government sectors, and the private sector. Additionally, YPs and entrepreneurs who possess the talent and skills and lead important projects are also targeted for data collection.

These individuals and organizations were chosen for interviews in order to provide a holistic view of the challenges and opportunities associated with leveraging Bangladesh's demographic dividend to advance 4IR. For instance, three experts from Youth Opportunities, ActionAid, and iEntreprene were selected due to their hands-on experience in mobilizing and empowering youth, which is crucial in developing a workforce that can actively contribute to 4IR. Since over 30-33 percent of Bangladesh's population consists of youth, these organizations offer insights into how young people can be engaged, trained, and empowered to transition into a future shaped by automation, artificial intelligence, and digital transformation. Meanwhile, YPs from Light Castle Partners, Bikash, and the School of Entrepreneurship Development were included to analyze policy, economic trends, and financial ecosystems that support or hinder technological

adaptation and innovation. Their insights help assess the economic feasibility of implementing 4IR in Bangladesh and provide data-driven solutions for bridging skills gaps and fostering inclusive economic growth.

Furthermore, participants from Noakhali Institute of Science and Technology Tetra, Bangladesh University of Engineering and Technology (BUET), Dhaka University (DU), Dhaka Medical and Institute of Business Administration (IBA) were chosen for their expertise in economy, health, engineering, technology-driven entrepreneurship, and innovation ecosystems, providing valuable perspectives on how technological advancements can be integrated into Bangladesh's industrial and other social sectors. The inclusion of an expert from Thammasat University and the International Union for Conservation of Nature (IUCN) Asia Regional Office adds an essential dimension of sustainability and environmental considerations in the context of 4IR. As automation and AI continue to evolve, it is crucial to assess their environmental implications and ensure that technological progress aligns with sustainable practices.

Additionally, the selection of Swedish entrepreneurs and sustainability-focused stakeholders, such as Tetra Pak and H&M (via Swedish collaborations), adds an international perspective to 4IR adaptation, particularly in integrating global best practices with localized innovation. The relevant expert from the Post & Telecommunication Division is also included to understand the current state of 4IR in Bangladesh. The young entrepreneurs who work in rural areas are also included to grasp the rural-urban divide as far as access to 4IR technologies is concerned. Another expert working in the United States of America (USA) has been selected to make a distinction between the progress of 4IR in developed and developing countries, such as Bangladesh. This carefully curated sample ensures that the research incorporates perspectives from policy experts, educators, entrepreneurs, industry leaders, and youth organizations, offering a comprehensive understanding of how Bangladesh can exploit its demographic dividend to shape a 4IR-driven future. Experts from NGOs such as the Bangladesh Youth Leadership Center

(BYLC) and Jago Foundation were interviewed since they are running various youth-led programs at present.

Four FGDs are conducted for this study. The selected sample of FGDs represents a diverse, multi-stakeholder perspective essential for understanding and implementing the 4IR in Bangladesh. Mainly, government and non-government officials and young people from various sectors have been included. The key criteria for their selection were their expertise, organizational influence, and direct engagement in youth development, technological adaptation, and entrepreneurship. For instance, the inclusion of SustainLaunch Labs for conducting two FGDs adds an essential dimension of sustainability and research-driven technological adaptation in the context of 4IR. In each FGD discussion, eight students from BUET, Ahsanalullah University of Science and Technology, Khulna University, North South University, and BRAC University, and eight young entrepreneurs across various sectors joined. At the National Youth Development Centre, Savar, which is a state-owned research center dedicated to youth empowerment through skill development and employment generation, two FGDs were conducted: one among officials, managers, and staff, and the other one is among the youth who are unemployed and came to take training at the centre.

One of the important KIIs was Aspire to Innovate (a2i), which is a government agency primarily working on innovation, integrating innovation, and utilizing proof of concepts (POC). If any POC is identified, they collaborate with relevant agencies and move toward implementation. Their main focus is on how innovation can be integrated into government services or any government-related opportunity, and how benefits can be derived for the target audience. Since they have youth-led programming, data is also driven from A2i through conducting a small discussion on SDG.

Four Research assistants (RAs), fluent in both Bangla and English and having prior experience in interviewing people, were appointed to help with the KIIs and FGDs.

They also assisted with the transcription of the interviews. The researchers, at the onset of this study, were involved with an extensive desk review. It was imperative to gain insights into the key concepts. Here, important articles, government policy papers, and relevant planning documents were reviewed.

The desk review was of great help in preparing the questionnaire for the KIIs and conducting FGDs later. Through the desk review, the researchers obtained ideas about concepts such as demographic dividend, the role of youth in technological advancement, 4IR and related technologies, youth potentials in the context of Bangladesh, typical challenges Bangladesh faces in relation to technology adoption, and typical challenges the youth are confronting while they are getting involved in implementing relevant policies. The desk review also enables the research project to select the relevant persons or institutions to collect data.

Next, this study conducted semi-structured interviews for KIIs to obtain data from the participants. The KIIs helped gain important insights into the problems. This type of interview was more open-ended in nature, thus has room for two-way conversation, which in turn is beneficial in exploring the ideas and opinions on how to transform the Bangladeshi youth into an army of resources which could implement 4IR in this country. An interview guide was prepared for the convenience of conducting the interviews.

3.1.4. Development of Questionnaire

For this study, a questionnaire was prepared for the experts. Besides, for conducting FGDs, a separate questionnaire was prepared to gather information from the youth. The questionnaire is prepared in both Bangla and English. The preliminary questions were asked for the respondent's demography, education, profession, and expertise on 4IR. A number of questions were asked about views on the demographic dividends, key components or characteristics of 4IR, differences in usage of 4IR in rural and urban areas, youth contributing to Bangladesh's economic

transition, the current situation of 4IR in Bangladesh, its prospects, and key challenges. Other questions were related to 4IR concepts, their current usage in Bangladesh, the level of support from the government and private sectors, etc.

3.1.5 Data Analysis Plan

The collected data is organized and analyzed subsequently. In order to analyze data from interviews and FGDs, the study resorts to thematic analysis, which is a means to reveal, examine, and report the patterns or underlying themes within the data (Braun & Clarke, 2006).¹³² The study illustrates a code hierarchy to easily convey the findings. Manual coding is applied to identify themes from the data. The study identifies the main themes and subsequent sub-themes from the analysis. The interviews and the FGDs are analyzed to identify the themes and ultimately the findings, which enable the study to come up with ways to get the youth involved with the implementation of the 4IR vision.

3.2 MANAGEMENT OF THE DATA AND ETHICAL CONSIDERATIONS

The research team has understood the confidentiality and the sensitivity of data. The data was mostly recorded with a voice recorder. For the purpose of analysis, the data were transcribed. The researchers and the RAs maintained a notebook/diary to jot down notes and other points.

The usual ethical protocols have been maintained. The questionnaire was designed in such a way that it would not result in any psychological damage to the participants. Also, the participants in the KIIs and FGDs were invited through a formal letter of invitation, and they were asked to sign a consent form. The participation was voluntary; they could withdraw anytime from the process. Also, the participants' identity was kept anonymous as a pseudonym was assigned to each participant while analyzing the data. It was also mentioned that the names of the participants would only be revealed if they provided permission to do so.

CHAPTER 4: FINDINGS

In the previous chapter, it was delineated that 4IR holds transformative potential for Bangladesh, with applications spanning multiple sectors like agriculture, manufacturing, education, healthcare, etc. Scholars have also identified these applications in various contexts, emphasizing their necessity for addressing productivity challenges, resource constraints, global competitiveness, and so forth. However, gaps in the analyses and data from the field suggest the need for a more comprehensive approach to leveraging 4IR technologies across the country. It also needs to be pondered that, despite various challenges and odds, Bangladesh has progressed significantly in the digital transformation at the micro level in international trade. According to an estimate by Inspira, the impact of 4IR will be in five major areas in Bangladesh, including agrifood, readymade garment (RMG), textile, furniture, tourism, and hospitality.¹³³ Notwithstanding the breadth of applications discussed, some significant areas remain underexplored in Bangladesh. The following are the specific areas in which Bangladesh has the potential to flourish using 4IR technologies.

4.1 PREPAREDNESS FOR 4IR IN PROSPECTIVE AREAS: ADVANCING GLOBAL CONNECTIVITY, EMPLOYMENT, AND INCLUSIVE GROWTH

Bangladesh's young population is dynamic, ambitious, and vibrant. They are coming from vigorous, energetic demographic groups and are playing a crucial role in shaping Bangladesh's future. Primarily, young people are very much related to the two words “entrepreneurship” and “innovation”. Besides, the impact of 4IR is more far-reaching than the previous Industrial Revolutions, and it is sector-specific. It is estimated that, on average, 47 percent of total employment in Bangladesh will be automated by 2041.¹³⁴ Sector-wise disaggregation indicates that 60 percent of jobs in the RMG and furniture sector, 40 percent in the agro-processing industry, 35 percent in the leather sector, and 20 percent in tourism will be advanced by

technological progress and automation.¹³⁵ The business and industry transformation will help in smart manufacturing, personalization, supply chain, and logistics. 4IR will help healthcare innovations. This estimation shows that the potential of 4IR in various sectors is immense, as mentioned below.

4.1.1 Industrial Sector

4.1.1.1 RMG

The economic sector includes the use of 4IR in various industries (tourism, manufacturing, and more), and among these, RMG plays a vital role in the country's economic growth. It can be argued that people are attempting to utilize this sector to some extent, but the country has not yet reached its full potential. It is recognized that incorporating technology and digitalization in this sector is urgently needed to conduct business and compete in the global market. Now, considering the existing level of progress, it is worth noting that in some cases, technology related to AI is advancing well. Also, this sector has already experienced some forms of automation. Looking at the labor statistics, especially the Bangladesh Labor Survey reports, it is found that the number of workers in the R&D sector has stagnated since the automation or industrialization of this sector. It is anticipated that this will accelerate in the coming years. But how will it be expedited, perhaps, would be the biggest question nowadays. There are 22 steps in manufacturing a garment. The textile manufacturing process has already become automated, and it has already been done and tested. However, managing quality control and sewing are the critical areas of automation. As informed by the Director of Light Castle Partners,¹³⁶

"We haven't been able to figure out reliable technology that would sew. We have cutting machines, which are automated. But no one can sew it, and that's where we have most of these workers. In fact, quality control is in one area, and sewing is in another area. So, these stages are still manual in a way. And it's expected that due to AI, there are already a few pieces of equipment that have been deployed for quality control. So, the number of workers has decreased in those segments."

Since significant women are working in the garment industry, they are a major strength of this sector. As remarked by the Research Officer, Ethical Trading Initiative Bangladesh,¹³⁷

“Women are already a big part of the labour force, and the RMG sector has been one of the main entry points, especially for young women into formal employment. But if we keep relying only on low-skill, repetitive production, we’ll hit a ceiling. That’s why integrating 4IR into RMG is not a luxury anymore; it’s a necessity.”

However, as mentioned earlier, over the next few years, more than half of the processes will become automated in this sector, and present jobs will be at risk within the next two decades. Although workers will be engaged, a lot of them will be replaced by machines. There is a new technology called SewBox, which can sew clothes independently. And their productivity per hour is three or four times more than that of 10 workers. So, they are quite productive to some extent. Indeed, there exist short-term and long-term ramifications of over-reliance on 4IR. For example, the short-term implication is that a lot of workers might get laid off in the next five years. The medium to long-term consequence is—since industry is transitioning from a labor or labor-intensive industry to a capital-intensive industry, the sector can move anywhere the buyers want. So, there is a term called ‘onshoring’, which might become commonplace. Therefore, there is a probability that a lot of factories will move near the destination market.

4.1.1.2 SME

Aside from the garment industry, the 4IR can be immensely beneficial for the SME industries and can help enhance market access and improve customer management. Nearly 30 percent of the country’s workforce is involved in SMEs across a number of sectors, like agriculture, leather, and furniture, and these sectors will be impacted heavily (especially concerning labor unrest) due to the automation process.¹³⁸ Thus, it helps enhance market access and improve customer management.¹³⁹ The country has also noticed progress regarding blockchain-based supply chain finance. United Mymensingh Power Limited, for example, imported 20,000MT of fuel from

Singapore using this process. In addition to that, in 2019, IPDC launched Orjon, the first-ever blockchain-based digital supply chain finance platform in Southeast Asia.¹⁴⁰ According to an estimate, a good number of jobs in Bangladesh will be facilitated by 4IR.

Currently, industries of Bangladesh, especially the garment industry, remain significantly dependent on human and semi-automated processes. Although the industry employs approximately 4 million individuals and has green-certified factories, it is deficient in automation and intelligent technology (Shabur et al., 2021).¹⁴¹ However, in this sector, there are some major constraints, including low broadband penetration and resource limitations. In this regard, Uygun (2021) fills this gap by suggesting smart manufacturing and cyber-physical systems (CPS) for the garment sector. Roy and Kayesh (2016) also identified that AI in manufacturing or blockchain for remittance systems could strengthen Bangladesh's economic resilience. While digital financial services and initiatives in the garments and IT sectors indicate progress, systemic barriers continue to hinder widespread adoption. Opportunities exist in fostering industry-academia collaboration, leveraging the youth demographic, and improving technological infrastructures. Islam et al. (2018)¹⁴² examine the integration of IoT in agriculture, AI in supply chain management, and automation in the RMG industry to boost productivity and global competitiveness.

Inspired by a passion for technology and recognizing a gap in affordable, quality tech solutions for SMEs in Bangladesh, the CEO of IniLabs Bangladesh¹⁴³ who co-founded a company to develop ready-made digital products that address real business problems globally. The challenges he shared included limited payment processing options and resource constraints. Despite these hurdles, the tech industry in Bangladesh is expanding, with many young professionals engaging in emerging fields like AI and machine learning. He shared that the government should improve infrastructure, simplify global communication and payment systems, host industry events, and encourage youth to learn new technologies to foster innovation. He stressed the need for government support to cut bureaucratic red tape and promote

the creation of indigenous tech products. The company's workforce mostly consists of individuals in their 20s and 30s. Overall, with a supportive environment, Bangladeshi tech talent is capable of significant innovation and growth. In a nutshell, observing these sector-specific insights, there would be broader implications of 4IR on Bangladesh's industrial market, and for this, the country needs adequate preparation to fully leverage this progress.

4.1.2 Social Sector

4.1.2.1 Education

In the education sector, although there is a huge transformation for Bangladesh in the coming days due to embracing 4IR, there are a lot of challenges. The inclusion of AI, machine learning, robotics, and big data analytics has an influence that reshapes educational practices. In this aspect, Elayyan (2021) explores the prospects of blockchain and AI in education for transparency and efficiency while emphasizing cloud computing for scalable reforms. In a similar vein, Nicholas Davis (2016) emphasizes leapfrogging technologies like mobile-based services, blockchain for financial inclusion, and AI in education. ICT adoption in libraries.

As of now, the University Grant Commission (UGC) has attempted to reform outcome-based education in accordance with the academic programs with 4IR requirements. In April 2023, the Bangladesh Computer Council (BCC)—known as the advocate of technological development—has taken numerous initiatives that include several programs like BanglaGovNet, Info-Sarker Phases II and III, Connected Bangladesh, as well as training over 236,000 individuals for enhancing human resource development and ICT skills.¹⁴⁴ Between 2010 to 2022, nearly 36,000 individuals (especially the youth) were trained in diplomas and other related short courses to prepare them for competing in the global market.

To reach the young generation of rural people, a distance learning method has been launched in some areas by NGOs. Children who enroll in English medium schools are well acquainted with digital gazettes and digital platforms for education, for

learning. Even the curriculum and learning process have been updated following international standards. Online learning platforms, such as educational centers in Bangladesh are teaching Bengali to foreign countries using digital platforms. These learning centers (Khan Academy) work as potential digital platforms for the young generation. These centers organize coding classes, boot camps, workshops, hackathons, and technology workshops so that the young generation can be engaged more in a global platform and can learn more about the culture of innovation and other problem-solving approaches.

4.1.2.2 Health Care

In health care, Bangladesh is progressing gradually by taking certain initiatives through AI, robotics, and the Internet of Medical Things (IoMT). In a recent study, it is reported that the potential of 4IR in the healthcare sector is simply “revolutionary”.¹⁴⁵ Due to 4IR service delivery and patient outcomes have enhanced, especially seen in some private hospitals. Earlier, people had to go from one floor to another. Now, there are AI-driven diagnostics that are seen in some private hospitals (e.g., Apollo). Therefore, due to this health strategy, diagnostics have been very specific, and the popularity of telemedicine is increasing. In order to accelerate the service, data privacy, and patient safety and security, the government has prepared a Digital Health Strategy, increased budget allocation, and adopted other legal and ethical frameworks. Islam et al. (2022)¹⁴⁶ emphasize robotics in healthcare and AI in education as transformative 4IR applications. They showcase scalable benefits, especially when implementing these technologies in underdeveloped areas. Telemedicine has emerged as a new area of service. A Doctor from Dhaka Medical College¹⁴⁷ informed that they are now using e-ticket, electronic health records, and IoT wearable devices for remote monitoring.

Despite some positive initiatives, this sector is facing some challenges due to inadequate infrastructure, a lack of digital literacy among healthcare professionals, resource scarcity, and other financial constraints. Various academics and experts suggested taking a number of constructive initiatives to overcome those barriers.

For instance, Rumi et al. (2020)¹⁴⁸ expand on this by discussing the role of blockchain in finance and AI in healthcare. However, they miss opportunities to highlight scalable success stories, a gap noted by Hossain (2024)¹⁴⁹, who recommends documenting concrete examples to inspire replication and policy adoption. Alam and Ogawa (2024),¹⁵⁰ IoT for supply chain modernization, and cloud computing for healthcare and education. Yet, the lack of discussion on localized challenges, such as digital literacy or infrastructure gaps, limits their recommendations.

4.1.3 Technical Sector

4.1.3.1 ICT

The ICT sector is gradually progressing with the embrace of 4IR. During the period 2020-21, Bangladesh earned US\$1.3 billion in exports, which contributed 0.76 percent to GDP. This has also created over a million jobs. It is also projected that by 2025, Bangladesh will be able to reach its exports of US\$5 billion, roughly.¹⁵¹ The government, in this regard, has a plan to increase 7-8 million professionals who can contribute to a knowledge-based and 4IR-led economy. Meanwhile, the awareness and activism of youth can help push for policies that foster technological growth. However, empowering them with proper training, resources, and guidance is essential to unlocking their full potential in driving 4IR forward. As stated by one of the former data analysts of Bangladesh Peace Observatory,¹⁵²

“The youth of Bangladesh are poised to significantly advance the nation's information and IT sectors by leveraging their adaptability and innovative spirit.”

By acquiring expertise in areas such as software development, data analysis, and cybersecurity, not at a large scale, though, they are meeting the industry's demand for skilled professionals, enhancing the sector's overall capacity. Their entrepreneurial ventures, exemplified by a wide range of startups, introduce innovative solutions that drive technological advancement and create employment

opportunities. Their active participation in policy dialogues ensures that youth perspectives are considered in decision-making processes, fostering a more inclusive and forward-thinking IT landscape.

4.1.4 Agricultural, Energy, and Environmental Sector

In advanced countries, all work will be done by machines in the agricultural sector. But Bangladesh is an agriculture-dependent country, and some people work in the agriculture-related field for almost half of the year. Then they go for alternative jobs so that the other small manufacturing companies could be significant, too. The agriculture industry uses sophisticated instruments for meteorological forecasts and soil assessment. Nevertheless, extensive integration continues to be limited (Bhuiyan et al., 2020)¹⁵³. Alam and Ogawa (2024) build on this by proposing AI for inefficiencies in farming.

As far as the renewable energy sector is concerned, in 2023, Bangladesh took some initiatives that include producing the Teesta 200 megawatt (MW) Solar Park which is the largest among 10 operational power plants in the country. It is a matter of hope that it can collectively produce 459 MW. It is also estimated that solar power has the potential to generate 50174 MW that can meet nearly 80 percent of the projected energy needs by the year 2041.¹⁵⁴

In the environmental sector, the initiative focused on 4IR is quite new. However, not on a large scale, Bangladesh provides direct funding in order to ensure environmental sustainability and address environmental-oriented challenges. For example, a2i primarily encourages young people in digital and technological fields. They give special priority to social innovations that address various problems. Since 2013, they have provided funding through the Service Innovation Fund (SIF), which offered 1 million BDT for promising solutions. If an individual or a team developed a solution for a particular problem, we would evaluate it with our team and provide this funding. Currently, SIF is no longer active. However, an example of SIF funding in the field of youth innovation is a project from a student at United

International University (UIU) who developed an idea on how to produce fuel from plastic garbage. Another idea focused on making used cooking oil reusable.

A few studies address the role of 4IR in environmental sustainability, which is critical for a country's climate resilience. Additionally, the potential of AI in urban planning, digital finance for rural populations, and localized IoT solutions for disaster management need more emphasis. By focusing on these areas, alongside fostering digital literacy and improving infrastructure, Bangladesh can unlock the full potential of 4IR for inclusive development. Linking these technologies to real-world challenges with concrete success stories, scalable policies, and targeted investments can ensure that 4IR becomes a cornerstone of Bangladesh's socioeconomic transformation.

Zaman and Islam (2022)¹⁵⁵ highlight applications such as automated manufacturing, AI-driven agriculture, self-driving vehicles, and smart disaster management systems. These technologies are crucial for addressing labor shortages, improving disaster response, and enhancing productivity. Although the importance of such innovations is underlined, how Bangladesh can overcome infrastructural and policy barriers to scale these solutions is not worked out. This critique is partially addressed by Philip Ross and Kasia Maynard (2021), who advocate for smart city technologies like energy grids and IoT-driven disaster management, focusing on urban efficiency and resource optimization. As remarked by one of the professionals of Action Aid,¹⁵⁶

"We talked about the importance of infrastructure and ecosystem, but these are the two major barriers. The primary reason is that those of us who are associated with the ecosystem, except for the private sector, are often unaware of the latest updates."

Consequently, reaching the inclusion of the ecosystem and striking a balance with the development sector becomes a crucial hurdle for Bangladesh. However, environmental data frameworks initiated and developed by the Bangladesh Environmental Statistics Framework (BESF) during the period 2016-2030 are

noteworthy that align with the objectives of the 7th Five-Year Plan and Sustainable Development Goals (SDGs).¹⁵⁷ This environmental and climate data development system helps enhance data-driven environmental policy. Besides, Green Industries Diagnostic (GID) assesses tools and parameters of waste management, green infrastructure, and eco-tourism, and simultaneously creates investment opportunities by ensuring low-carbon development.

Nowadays, the youth are engaging in different environmental activities (like COP 29 and COP 28). But earlier, they did not even know much about COP and climate-related issues, but due to the mercy of digital platforms, they are engaging in various social platforms like Facebook, Twitter, and others. Nowadays, youth protest about climate change and climate justice issues, and they are working for the community. A new initiative, which is related to the Orange Bond by GoB. Launched in collaboration with the United Nations Development Programme (UNDP) and Impact Investment Exchange (IIX), these bonds aim to catalyze sustainable growth and inclusive economic recovery by prioritizing gender equity and climate action.

4.1.5 Service Sector

4.1.5.1 E-Commerce and Social Enterprise

Youth are also coming into the service sector. It is observed that certain areas, such as pharmaceuticals, furniture, food processing, banking, and in some other service sectors, technologies related to AI have already been introduced. By using digital platforms, young generations, who are innovative, have been involved in different innovative businesses like e-tech, e-commerce, and social enterprise sectors. By using entrepreneurial spirit, the youth are creating new job opportunities and business models, and by using the digital platform, they are attempting to connect globally. They are working in freelancing by doing different courses from e-platforms like edX and Coursera. Upwork and Fiverr are some of the freelancing platforms that are bringing dollars to the countries. Using Facebook, entrepreneurs run live programs about their products. Few are engaging in software development,

digital marketing, and attracting and holding international clients. In that way, they have engaged in a global digital service.

In the banking sector, mobile banking, automated customer service, and digital payments are getting popular in Bangladesh. In terms of the transport sector, ride-sharing apps (Uber, Pathao), delivery automation (Paperfly, Steadfast), IoT-based fleet tracking, digital mapping, and traffic control have been introduced for greater urban mobility. Similarly, in the tourism sector, online booking systems, digital payment integration, and virtual tourism initiatives are enhanced to ensure greater accessibility.

Nowadays, internet penetration is praiseworthy, reaching nearly 75 percent, along with mobile penetration at about 69 percent.¹⁵⁸ This large-scale connectivity system helped to spread the usage of 4IR across different districts in Bangladesh. In this aspect, social media is an important means of facilitating work, particularly for a certain segment, such as women, the rural population, and marginalized communities.

4.1.5.2 Mobile Banking Service

Although 4IR covers a wide range of ideas in Bangladesh, it has not been widely adopted in daily business. Notwithstanding that, in relation to business, people have different online payment apps, and those are also part of the technological shifts that are taking place in recent times. Introduced in 2011, Bikash has become a popular financial service in the country that includes millions of people living in rural and remote areas. Other useful financial transactions through mobile banking services are Nogod, Upai, and so forth. Aside from cities, these are acceptable services for users while receiving and transferring money and paying bills without a bank account. People adopt this new initiative because it simply requires fundamental literacy. Unlike these, the use of advantage technology (AI, machine learning, or robotics) in various service systems is not that popular in the country since the implementation of these tools requires prior expertise. In this context, the significance of literacy and technology, as well as skill development, is needed.

4.2 4IR: Prospects, Opportunities, and Expected Benefits for Youth

Bangladesh's youth sector has immense potential in various sectors that have already been discussed above in a precise manner. Now, this section is developed primarily based on the experts who work in the private sector, NGOs, and international organizations (INGOs) to understand the prospects and opportunities in 4IR. According to the experts, the prospects for youth in the case of 4IR are immense. Because, for Bangladesh, 4IR means focusing more on Gen X, Gen Z, and millennials who are playing a pivotal role in the labor market, socioeconomic activities, political transformations, and cultural changes. According to the Bangladesh Bureau of Statistics (BBS), the youth are mostly between 15 to 29 years old, who are a growing and diverse population. They can bring different ideas, aspirations, and talents that increasingly become a driving force behind national development. Currently, nearly 3.5 million students are enrolled in the National University, and every year, 500,000 graduates enter the job market. Therefore, the country's goal is to develop its skills according to market demand.

4IR is also known as 'Industry 4' since these physical, digital, and biological technologies are transforming industries and society as a whole. While thinking about 4IR, the usage of its parameters (AI, IoT, robotics, blockchain, biotechnology, and quantum computing) in multiple sectors is thought of. For example, IoT is device-based tools that communicate with each other and create a small, smarter world. It also enhances automation, precision, and efficiency in workforces mostly used in agriculture, food security, health, and even for some other purposes. A number of organisations are currently working on various components of 4IR. From the SDG discussion, it is known that a2i provides policy support, facilitates the ecosystem, and facilitates training on digital literacy. While the ICT division funds and accelerates IoT and robotic startups High-tech Park Authority accelerates IoT/robotics startups.

While considering AI, it can be said that this tool is capable of processing data, adapting, and making decisions without any human intervention. On the contrary, robotics is essential to participate in automated systems, mostly used in factories

and logistics. Nowadays, in advanced countries, robots even serve food at restaurants, and Bangladesh is far behind in adopting this practice. Since robotics is lowering the cost and human error in production, logistics, and other sectors, there will be an increasing demand for new technology workers. This transformation requires technical skills in some special areas like software development, data science, and cybersecurity. A number of universities, such as BUET, BRAC, and MIST, work on robotics, IoT research, automation, and other AI solutions, and the students at these universities participate in global competitions.

In general, Bangladeshi youth are very adaptive and resilient. However, they face many hurdles due to the problem of unemployment stemming from insufficient working skills. Currently, the country has created many graduates from tertiary levels, but the market does not offer enough decent jobs for them. This has created a lot of underemployment as well as unemployment issues, thereby creating pressure on the workforce. To solve this problem, BYLC comes up with the idea of soft skill development programs (e.g., “powher” for female empowerment, industry founder, etc.) along with venture, startup, and business initiatives to get rid of something from traditional job markets. As informed by the L&D Specialist of BYLC¹⁵⁹,

“Today’s youth are increasingly looking beyond the traditional job market. However, limited resources often prevent them from pursuing entrepreneurial opportunities. To address this gap, we connect them with industry experts and provide support to strengthen their soft-skill competencies.”

Despite all that, because of the existence of informal sectors, as well as, to some extent, entrepreneurship, the youth have shown a lot of determination to stay active and to earn their own living. This is perhaps the emergence of digital technologies as well as social media. Many of them, especially females, have entered into e-commerce. They started their own business, either cooking shops or cooking items

online. This is a glaring example of how technology is leveraging Bangladeshi women. As narrated by the Co-founder of Youth Opportunities,¹⁶⁰

“Bangladeshi people are tech-savvy and very adaptive. To me, we kind of adopted technologies like smartphones or the internet quite fast.”

It has already been observed that in Bangladesh, 4IR follows a certain process and advancement that has created immense impacts and offers different opportunities. For example, in 2006-2007, Bangladesh did not have high-speed internet. But despite all that, there was an attempt to build that digital infrastructure and to build that internal capacity of both humans as well as the institutions. So, the youth (especially those living in rural and remote areas) lag a lot behind in terms of the digitization process. But one of the good things about the young Bangladeshi people is that they are very adaptive to technology. They have already adopted certain technologies like smartphones and the internet quite quickly. Expanding beyond the city level, youth living in rural and remote areas can be connected via online schools. Examples are online school initiatives by 10 Minute School (MS) and Jago Foundation. 10MS offers comprehensive online classes at the primary and secondary level, skill development, vocational training programs, and entrepreneurship programs for professionals. Jago Foundation, on the other hand, runs youth-led programs with 55,000 volunteers in 495 upazilas. The Programme Manager of this organization informed that partnering with TikTok, Plan International, and embassies, they run 252 training centres for awareness building and “*shabdhane online e*” programmes, for ensuring digital safety and security.¹⁶¹

It has become evident that 4IR holds the potential to bring justice and equity to society. In the aftermath of the July uprising in 2024, the Bangladeshi young generations have embraced 4IR technologies as a means to drive social justice and inclusive transformation. Currently, they have substantial political engagement too. Due to this advancement, the internet, IoT, and other things, young people have been politically and socially conscious in recent times. They are aware of

incremental sustainability, human rights, and gender justice. By using social platforms, they raise their voice and influence government policies. In addition, there have been movements in digital platforms and digital learning with a strong commitment to a better and more equitable future. These efforts, nonetheless, help to reduce gaps and create more opportunities for the young cohort to cope with the rapidly growing digital landscape. As voiced by a Data Analyst,¹⁶²

“The young people of Bangladesh are one of the country’s greatest strengths. They are energetic, adaptable, and politically conscious, with a strong connection to the world, which positions them well to lead progress in the 4IR. Their growing interests in digital skills, entrepreneurship, and innovation give them the potential to drive economic growth and technological advancement.”

In sum, 4IR is reshaping industries, economies, as well as societies through advanced technologies. However, skill gaps, inadequate infrastructure, and limited access to advanced technologies pose significant challenges for them. The next chapter aims to address these issues in detail to have a deeper understanding of the key barriers and identify potential solutions.

4.3 IMPLEMENTATION OF 4IR: KEY CHALLENGES

In the previous sections, it has been delineated that Bangladesh has made strides in adopting 4IR technologies, particularly through initiatives like sector-specific applications in garments, agriculture, healthcare, etc. However, significant challenges remain in infrastructure, education, policy alignment, and inclusivity. The country faces notable hindrances in transitioning to the 4IR owing to its dependence on antiquated industrial methods and technology. The country, aiming to achieve developed nation status within the next one or two decades, must confront these distinct obstacles while capitalizing on the possibilities offered by the 4IR. This chapter, therefore, examines major barriers to Bangladesh's preparedness for 4IR and the obstacles associated with its implementation while drawing insights from wealthy nations. In this section, it is also argued that to fully harness the 4IR and ensure sustainable development, Bangladesh must address

related challenges in relation to infrastructure, education, governance, and collaboration. These challenges, nevertheless, can bridge existing gaps, promote youth inclusion, and leverage the country's demographic dividend.

4.3.1. Structural and Policy-Oriented

4.3.1.1. Concerns for the Workforce due to the Digital Divide

In Bangladesh, a considerable segment of the labor force is unskilled, raising concerns that automation may result in job loss. Concerns further arise that, similar to job reductions, this may exacerbate unemployment concerns and other related matters. However, due to growth and the advent of 4IR, a lot of outsourcing work has emerged that requires high intellectual input, though this may become redundant in the future. Thus, on one hand, AI or the 4IR will create new sectors and industries, on the other hand, it will promulgate the digital divide. Due to these advancements, some groups will be winners using some form of mechanism, while other groups will be left out. Since blue-collar workers will essentially be left out, they will not be the main beneficiaries of 4IR. As shared the views by an academic from the Noakhali Institute of Science and Technology,¹⁶³

“...4IR has a large impact on the workforce. If we transition into 4IR, there will be some job displacement and new job creation as well. However, the crucial challenge is the skill gap that we are facing now.”

Meanwhile, educated youth might find themselves in more appropriate positions to thrive, and they can earn a living in this dynamic job market. In fact, 4IR in Bangladesh has generated a lack of a competent workforce, which is intricately linked to educational inadequacies and a lack of proficiency in modern technologies such as AI, IoT, and blockchain. Significant initial investment expenditures provide an additional obstacle, given that Bangladesh is a resource-limited nation.

4.3.1.2. Lack of Infrastructure

A significant difficulty identified is the deficiency of infrastructure and types of equipment across the country. All those 4IR technologies need connectivity and data processing capabilities to be implemented all over the country. Unfortunately, as it is observed, the country does not have seamless network connectivity in every part of the country, particularly in remote areas. The network is usually provided through a few methods—microwave network via network towers; the broadband network, which is provided through optical fiber cables and installed underground all across the country; and, in places that are generally inaccessible by both network towers and the optical fiber—like in the Hill Tracts or islands. For example, Bangladesh can provide a network through satellite. But so far, the country has not been able to fully implement this last method in remote places. This has shown that large-scale connectivity is still lacking in connectivity.

Moving on to data processing, one key concern that needs to be highlighted is whether Bangladesh will be able to process a large amount of data within a very short span of time. Where is the country up to now in this regard? Indeed, the country needs to improve its bandwidth capacity in order to get rid of this barrier. Currently, Bangladesh gets its required bandwidth from the submarine cables. For example, SEA-ME-WE 4 and 5, one of which ends at Cox Bazar and the other at Kuakata. Bangladesh receives around 2.8 TB of bandwidth from both of those, which is not even 3 TB. The country already has a contract for the 3rd submarine cable, SEA-ME-WE 6, with the consortium to have it installed by 2025. If it becomes fully operational, Bangladesh should be able to get around 6 TB of bandwidth. Bandwidths can be imported and exported, too. International Terrestrial Cable (ITC) is another method of importing bandwidth. Unfortunately, the bandwidth the country has is not any more than between 3-4 TB, which is one of the key hurdles as far as infrastructure is concerned. If Bangladesh does not increase bandwidth capacity, it will not be able to implement 4IR since its data processing capacity will be subpar. As added by a former Additional Secretary,¹⁶⁴

“...if we don't plan early and start the infrastructural development process, soon we will be faced with a large-scale bandwidth crisis. Hence, we should try to

incorporate the 4IR technologies in the field of education, agriculture, health, and various other manufacturing industries.”

Inadequate digital infrastructure, characterized by unstable internet access and a deficiency of technical hubs, obstructs the implementation of innovative technologies. This is exacerbated by inadequate electricity infrastructure and cybersecurity issues (Islam et al., 2018).¹⁶⁵ According to the Co-founder of Youth Opportunities,¹⁶⁶

“We don’t have such a kind of leverage on the promises of the 4IR since the country does not have proper infrastructure. Although the government tried to invest a lot in this, in some cases, those investments were not efficient or effective, but rather resource-consuming and full of corruption.”

Thus, insufficient infrastructure, poor connection (especially in rural regions, and restricted technical understanding are the key concerns nowadays.

4.3.1.3. Deficiencies in Policy

Unlike the developed countries, which enjoy the benefit of years-long investment in their infrastructure, Bangladesh’s investment is comparatively less in this arena. Bangladesh is trying to adopt this technology without having a complete plan as to how this is going to build on the next level of the country’s growth and development. In many cases, these initiatives are taken by the government, having its own political or personal agenda in mind. This does not necessarily reflect the needs of society. In Bangladesh, a lack of comprehensive regulations from the government is a great barrier. The public sector even lags in adopting advanced technology, introducing ethical issues, and establishing proper mechanisms for cybersecurity concerns. Still, there is a high level of bureaucracy and no interconnections between the different departments and ministries. There is no clear legal framework in the country that shows how 4IR will work, be implemented, evolve, adapt, and enact forward-thinking laws. In this respect, some experts raised

questions about the roles of various institutions. An ICT expert exposed his view that,¹⁶⁷

"I'm not sure if they [government institutions] have done a significant positive change to date. For example, a2i is supposed to be that incubation center where these ideas could flourish. But what happened next? Were there any impacts? Ultimately, it's also about hitting the market, providing value to the clients, and then earning money. If that doesn't happen, then all our infrastructure is in vain."

So, it is important to look back and identify the key policy frameworks where there is room for improvement. It can be related to access to finance, medical technology, genetic engineering, or some other areas.

4.3.1.4. Lack of Public-Private Partnership

Bangladesh is struggling the most in attracting the youth to get involved with the implementation of 4IR with incentives. The country lacks a comprehensive plan from the government to achieve that. Most of the IT specialist youths are employed in the private sector, and in a competitive, in some cases, exploitative market. The government has limited capacity to promote the idea of 4IR in particular. However, the 4IR, once implemented, will encompass many public production and manufacturing sectors managed by the government. What the government can do is to incentivize this sector to attract the youth. Providing the necessary incentives will be able to make them more innovative and enthusiastic in this sector, which will also lead to skill development. The former government expert shared his views as,¹⁶⁸

"At the moment, the biggest challenge the country might face in engaging the youth is the lack of incentives and opportunities. I don't see how they might be tempted to choose Bangladesh over abroad to offer their specialized services since there is limited opportunity, incentive, or demand in the domestic market. We wouldn't expect an IT graduate capable of working in Google or Amazon to stay behind in Bangladesh when we can't provide a comparable incentive, would you?"

In Bangladesh, there is a lack of industry-academia partnerships. One reason is that many times, the academics are not very involved with consulting work for private sector organizations. Most of their consulting work is with government entities or development partners. So, there is a gap in the private sector's needs. And this has been a problem for the last 20 years.

4.3.2 Industrial and Other Sector-Specific Problems

Addressing sector-specific problems is a great challenge, and participants in FGD also agreed this quite boldly. For example, in the healthcare sector, addressing mismanagement, improving connectivity, inadequate access to immediate medicine, and insufficient personnel in rural areas are identified as key barriers. Similarly, the agricultural industry is hindered by farmers' insufficient awareness of contemporary growing techniques. Both industries are seen as domains where 4IR technology may have a revolutionary influence.

In the industrial sector, it is revealed from the findings that a considerable segment of Bangladeshi industry continues to depend on technology from the 1st and 2nd Industrial Revolutions. Clusters like Kumarkhali Textiles in Kustia persist in using antiquated equipment, which diminishes the competitiveness of their goods in worldwide marketplaces. The Bagerhat Coconut Oil cluster has challenges owing to antiquated refining methods (Abdin, n.d.).¹⁶⁹

Moreover, there is an absence of explicit governmental initiatives to promote and enable automation and technology integration in sectors such as ready-made garments and shipbuilding. Tax incentives and subsidies for SMEs are inadequate (Islam et al., 2018). Another major challenge is the lack of coordination and alignment between policymaking, technological expertise, and implementation sectors, which significantly hampers effective progress. Additionally, the disconnect between STEM research and the policy (bureaucratic) sphere limits the creation of integrated, evidence-based strategies essential for driving innovation.

Although the software sector is showing improvement, the hardware infrastructure remains underdeveloped, further slowing technological advancement and adoption.

In many cases, Bangladesh is not fully ready to embrace the latest equipment of 4IR. One example of a self-driving car was never thought about before, but it has now been used in various developed countries. Although it is still a test business, it can become the norm in the future. Being an overpopulated country, excessive dependence on 4IR can have negative repercussions in the manufacturing sector and the overall job market in Bangladesh.

4.3.3 Technical

4.3.3.1 Technological Obsolescence and Mismanagement

Technological obsolescence or backwardness is regarded as one of the key hurdles to the effective implementation of 4IR in Bangladesh. Lack of resources has worsened this problem. Citing the example of Bangabandhu Satellite launched back in 2018, it can be argued that the satellite has around 60 percent unused bandwidth left. With an estimated lifespan of around 15 years, it has been over 7 years since its launch, but it has not been used to its full potential. The management of the satellite company was weak, which has led to this underutilization for so long. However, the unused bandwidth from it can still be salvaged and used properly.

4IR will transform the entire production system into a mechanized one, but nearly 20-50 TB bandwidth will be needed to achieve such a feat. The previous Industrial Revolutions, nevertheless, led to the lay-off of blue-collar workers and they have been witnessed and experienced over the last 150-200 years. From the 1st to 3rd Industrial Revolution, factory workers created the necessary growth for more job creation. Unlike these three Industrial Revolutions, 4IR will lead to not only job losses for blue-collar workers but also for white-collar workers. In this aspect, AI is a game-changer. As said by the Director of Light Castle Partners,¹⁷⁰

“We don't know what might happen in the next 5-10 years. The status quo might be radically different compared to where we are right now. So, it's a matter of concern. So, in a way, we are at a black swan inflection point.”

Another major setback is that Bangladesh has still not introduced the use of 5G technology countrywide on a commercial level. This will greatly hamper data processing in the coming days. The country has not developed the infrastructure to be able to implement it seamlessly. Whereas it will need a certain level of spectrum to use 5G technology. Bangladesh does have a good amount of spectrum, but it has a different problem there. It is quite expensive, in other words. For example, 1 MHz of spectrum costs around 10-15 million dollars. For 5G, an operator will need around 15-20 MHz spectrum, and that means a few hundred million dollars. No operators will be keen on making such a large amount of investment. That is why spectrum prices must be regulated during auctions by the pertinent management authority or allow the operators to pay in installments to make them interested in commercially introducing 5G technologies.

Even after the country develops the infrastructure necessary for using the 4IR technologies, it does not have any specialized labs or research facilities to ensure whether the 4IR technologies the country will have in the future meet the standard or not (IoT and Sensors, for instance). Bangladesh needs to test whether these products are standard before implementing them. The International Telecommunication Union (ITU) has a fixed standard for these technologies, which the country has to maintain consistently. In fact, Bangladesh will need a specialized lab for 4IR industrial products and specialized researchers as well. Also, Bangladesh cannot simply import all these products either, since it has limited foreign currency. So, the country will also need to develop local production capability accordingly. In brief, for now, these are the biggest challenges Bangladesh will be facing before anything else.

4.3.3.2 Lack of Diversification and Innovation

Diversification and innovation are keys to development and growth. In industries in Bangladesh, particularly within the SME sector, there is a lack of product innovation and diversity. This constrains young people's capacity to penetrate export markets, as shown by stagnating design and manufacturing techniques in textiles and other sectors. While Bangladesh has made progress in IT services, digital governance, and automation in certain sectors (e.g., RMG), challenges persist because of a lack of STEM education, innovation, and limited access to digital tools. Scholars agree that leveraging Bangladesh's demographic dividend and youth potential is essential, but most fail to provide detailed strategies for youth inclusion. Only a few, like Elayyan (2021) and Hossain (2024), touch upon education reforms or startup incentives that could directly engage the younger population. According to the Co-founder, Youth Opportunities,¹⁷¹

"... the main problem that I see in terms of getting the competitive edge is that we are kind of replicating or adopting different technologies that exist in the global arena, rather than necessarily developing or innovating our own systems or our own ideas. So, what happens is, it's about giving leadership to others in terms of innovation."

Another issue is, the country's ecosystem, or economy, is not R&D focused. The country has limited R&D scope or limited innovation scope. Here, most businesses still focus on traditional production methods, where digital transformation has not yet taken place. Entrepreneurs in Bangladesh often need access to essential information on contemporary machinery, pertinent suppliers, and suitable technology. The lack of platforms such as Alibaba or Indiamart intensifies this divide, obstructing industry modernization (Abdin, n.d.). The vocational institutions in Bangladesh do not have modernized curricula to include AI, robotics, blockchain, and cybersecurity. Indeed, an overhaul of the operational curriculum

and focus on installing the skills that are necessary to leverage 4IR and set up an innovative system.

Bangladesh is currently witnessing an emerging startup culture, but the policies are not yet startup friendly. The country is not doing well in ease of doing business and supporting startups. Especially, young startups are facing numerous challenges, including policy-level barriers to launching and scaling their startups. A lot of incubators and accelerators are trying to support young entrepreneurs, but the country also needs stronger policy support, which would help these startups thrive and grow.

4.3.3.3 Adoption of Technology

The economy of Bangladesh is mostly dependent on the RMG industry, with little input from other sectors like pharmaceuticals, leather products, and agro-processing. This reliance diminishes resistance to global economic swings (Abdin, n.d.). Certain aspects of 4IR, such as robots and IoT, are used to a limited extent. The absence of information among policymakers and industry leaders about technology necessities further impedes implementation (Islam et al., 2018).¹⁷² Industries are reluctant to embrace costly technology because of the presence of inexpensive labor and the substantial upfront expenses associated with automation. A considerable number of proprietors remain skeptical about the enduring advantages of 4IR technology (Shabur et al., 2021).¹⁷³ For example, in the case of high-tech parks, Bangladesh does not have much investment, nor does it have skilled people who will go or work in this area. As a result, these investments are kind of futile right now, and it is not giving the country any return whatsoever and becoming a whitening effect.

4.3.3.4 Cyber Insecurity

Cybersecurity is recognized as a critical concern, necessitating considerable investment in research and development. Additionally, factors such as insufficient

understanding, societal shame, corruption, and inadequate enforcement of environmental regulations hinder advancement. Cybersecurity is a significant problem since increasing occurrences of fraud and hacking jeopardize digital progress. Furthermore, corruption and inadequate environmental laws, including poor compliance with effluent treatment plant (ETP) requirements, impede development.

In the case of Bangladesh, there is also a lack of awareness regarding data privacy, cybersecurity, and the ethical use of emerging technologies. As said by a Data Analyst,¹⁷⁴

“.... many young people struggle with the psychological resilience needed in the digital age, making them vulnerable to issues like online stress, misinformation, and exploitation.”

4.3.4. Social

4.3.4.1 Gender Gap and Social Inequality

Gender gaps, along with social inequality, are still prevalent in Bangladesh. Girls, especially in rural areas, have less access to education, career opportunities, and digital literacy. Therefore, it is a challenge to ensure that women are fully participating and benefiting from 4IR. The biggest role, however, is for the government to play. The concept itself is not very well known among the people in our country, and even among the youth, it is quite vague. Even those who are aware of it may find the prospects of 4IR pretty bleak in our country's context. Therefore, what is needed first is mass awareness and skill development. Education from a very early level will be needed to familiarize students with the concept, especially focusing on the underprivileged segments, such as females.

4.2.4.2. Skill Gap and Lack of Competency

In the global South (in particular in Asia), a large pool of people is youth, whereas there is a declining population in many developed economies, including Germany, Japan, and the US. So, if migration increases, then there will be opportunities for

youth to be engaged in the Knowledge Process Outsourcing (KPO) industry or the freelancing industry. For example, the KPO industry does interpretation for radiological tests in diagnostic centers. Since doctors are very expensive in the West, the results are sent to this part of the world, particularly in India and Vietnam. Unfortunately, Bangladesh is struggling to get into this competitive market due to a lack of skills and competency.

It cannot be denied that over time, technology is changing, and it is inevitable. But the problem is, we lag behind in terms of preparation. Although there are a number of government institutions that are currently working (e.g., A2i), the country has a shortage of technical training-providing institutions. One of the fundamental issues that the youth face in the job market after graduating or when seeking a job is first their skills do not match what the companies require, and their education is not up to date. As told by the Former Human Resources Personnel of IUCN,¹⁷⁵

“We have not advanced and are still kind of stuck with our traditional methods. But I think it would be great to see how youth can create opportunities by themselves. I believe we are already seeing it to some extent, mostly through personal efforts. We do have some amazing talents here in Bangladesh who are working on various projects that are technologically advanced, but I think what they need is more structure and robust policy backup.”

The educational framework in Bangladesh is misaligned with the competencies necessary for 4IR. Curricula lack critical thinking, technological abilities, and digital literacy (Moavenzadeh, 2015)¹⁷⁶. That is, the significant hurdle is the lack of access to quality education and training opportunities, particularly in rural areas, which limits many young people's ability to acquire the necessary skills in emerging technologies like AI, robotics, and data science.

In many cases, it is seen that the youth from decent universities are not hireable due to a lack of basic skill set. They become graduates in such a way that they're able to navigate through these existing challenges. The Director of Light Castle Partners stated,¹⁷⁷

“We have to rethink the education system in a different way. Because at the end of the day, the four-year undergrad and the master's degree are outdated. University education should be like a Netflix subscription. People should have the scope to come back whenever they need it and figure out the skill gaps. In fact, re-skilling is the call of the game in 4IR.”

Due to a lack of an up-to-date education system, there is a huge gap between formal education and the skills demanded by jobs, and the digital relations and connectivity between the young generations. In a survey conducted in 2021 by the Bangladesh Institute of Development Studies (BIDS), 66 percent of national university graduates became unemployed because of a gap between the traditional education system and 4IR-related job market demands.¹⁷⁸ This demands a balance between the two for the overall upliftment of the young generations. Another related challenge is the lack of structured pathways for students and professionals specializing in 4IR-related fields. Many young people who study topics face difficulties in finding opportunities to conduct meaningful research or apply their knowledge in practical work settings. This lack of outlets often leads to the underutilization of talent and missed opportunities for innovation.

4.3.4.3 Urban-Rural Divide

There is a skill gap between the youth of rural and urban areas. It is worth mentioning that the youth studying in urban schools have access to computers and smartphones, and they can easily get information from the world. Unlike them, in rural areas, the scenario is completely different. There is an ample gap in accessibility in education. Another major problem related to 4IR expansion in rural areas is the lack of knowledge and system about the exact support that the youth need in rural areas. The country lags in reaching those who are interested and spreading 4IR at the grassroots level. The country still stays at the surface level.

In this aspect, the major issue is the urban-rural digital divide, where young people in rural areas often lack access to reliable internet, modern technology, and quality

training programs, putting them at a significant disadvantage compared to their urban counterparts. This disparity limits equal opportunities for involvement in 4IR-related activities. The major problem for the youth (especially youth living in rural areas) is that the opportunities and spaces are not clear. As raised several concerns were raised by an expert from ActionAid,¹⁷⁹

Where will they [the youth] work? Where will they show their resilience? What new direction will they take? Who will give them a new direction? What are the small things that need to be improved? Without primary education, how do we express the opportunities? How do we make them experts? If they don't get a new direction, however, they are not getting a new window. Then there is no use in being resilient.

As far as infrastructure and connectivity in rural areas are concerned, it can be said that limited internet access is a big problem that creates a huge division between the youth of rural and urban areas. Worldwide, people are enjoying the dividends of 5G mobile networks, whereas Bangladesh has just entered 5G, but is still heavily dependent on 4G and 3G. Especially in rural areas, as of now, there is a lack of reliable, fast internet connectivity along with widespread accessibility. Youth living in rural areas have a shortage of skills and are less experienced in AI, IoT, cloud computing, machine learning, data science, cybersecurity, robotics, and programming. On the contrary, power supply and energy issues are one of the main concerns to access these facilities. One positive aspect is that the young generation is enthusiastic about learning new things, especially technology-based things. Arrangement of training and other skills could reduce this gap.

4.3.5. Ecological and Political

There are ecological and environmental concerns related to 4IR. Concerns about environmental deterioration from heightened industrial operations and probable socioeconomic inequalities stemming from uneven access to technology need attention (Moktadir et al., 2021)¹⁸⁰. Young women and other marginalized groups are lagging due to socioeconomic discrimination. Bangladesh is a male-dominated society, and the potential of young women is less realized. If they are given better opportunities, surely, they can show their skills. In that case, support can be given

by government agencies like the A2I or ICT ministries for building this ecosystem. But the government, private sector, and training institutions cannot reach that place yet. Besides, the connection with the private sector is very poor with the government. The relevant ministries and mechanisms in the government are distancing themselves from research and technology. As a result, the ecosystems and environmental orientations are not being created and introduced, and the training of young people is not being provided.

Bangladesh is already among the climate-vulnerable countries, and people are facing various forms of vulnerability. There is an environmental concern that, if there are too many digital activities, data centers, power, and electronic waste, the carbon footprint will increase. Although Bangladesh is trying to minimize its carbon footprint and other environmental challenges, it may be fatal due to overuse of digital tools or industrial waste; so, Bangladesh must be prepared.

Similar to Bangladesh, it is further anticipated that due to the adverse environmental situation, there will be some negative impacts on other least-developed countries that might exacerbate more challenges. Primarily, marginal people and day laborers are losing their jobs in Third World countries. Due to carbon emissions, in particular, Bangladesh might not be able to reap the full benefits of 4IR since it must stop somewhere due to this concern. Then the young generation may be demotivated and turn back to their traditional jobs. This type of problem might not be faced by people from the First World countries. Waste is also a threat to biodiversity, particularly in the production and reproduction systems. Those who are involved should be brought under social safety nets by the government as well as the private sectors in the transforming periods of 4IR.

Bangladesh, although recognizing the promise of the 4IR, is in the early stages of implementation. Numerous participants in FGDs observed that the disparity in comprehension and implementation of 4IR technologies across various sectors recognized the nation's difficulties in competing internationally, owing to structural and systemic challenges. The discourse started by underscoring the need to

incorporate 4IR technology into industry, healthcare, education, agricultural, and environmental domains. Despite certain advancements, the nation remains deficient owing to inadequate infrastructure, insufficient awareness, and limited expenditures, among others mentioned above. Taking into account the key limitations, the next chapters provide some policy suggestions for the proper execution of 4IR in Bangladesh.

4.3.6 Psychological

Bangladesh might face challenges in implementing 4IR due to the skill gap and workforce readiness. The current workforce at this moment lacks training in advanced digital skills such as AI, machine learning, or automation. The country has engineering universities, and they are producing, obviously, excellent graduates every year, but still, today it does not have enough ecosystem structure or ecosystem strength to hold them. Most of the finest graduates the institution is producing are leaving the country, fearing that there will be no job opportunities in promising sectors, unlike those in developed countries. In search of higher salaries and better recognition, the young generation tends to go abroad. Therefore, “brain drain” has been a well-documented concern. As opined by the Co-founder, Tetra,¹⁸¹

“I think we lack an infrastructure gap to attract talent and to keep talent here within the country. So, this skill gap might be a challenge in implementing 4IR in Bangladesh”.

The issue of brain drain has been a concern for several reasons in Bangladesh. It is quite obvious that young and energetic individuals across the country seek opportunities to enter the global economy. If Bangladeshi talents work abroad, they also bring something positive to the country. However, some experts opine that it might have a detrimental effect in the long run if this skilled generation does not invest back in Bangladesh. On the contrary, if bright individuals remain in the country, they will fail to produce significant output due to a lack of opportunities.

In that case, their potential will be wasted fully. If these intellectual youth are underutilized in the nation, they will not make a significant contribution to the country.

From the above analysis, it can be summed up briefly that Bangladesh is currently facing numerous challenges in implementing 4IR in Bangladesh. However, to maximize the demographic dividend, Bangladesh must invest in digital literacy, technical education, and innovation-driven policies. Collaboration between the government, private sector, and academia is essential to foster an adaptive workforce. Addressing automation risks and ensuring inclusive growth will be critical for sustainable development in the era of 4IR. The next chapter, thus, gives a thorough discussion of these issues for maximizing the potential of 4IR in Bangladesh.

CHAPTER 5

DISCUSSION AND CONCLUSION

The positive potential of Bangladesh's demographic dividend lies in its ability to drive economic growth and societal development, particularly in the context of 4IR. A youthful workforce, if adequately skilled, can become a catalyst for innovation and industrial transformation. Various experts highlight the importance of education, vocational training, and digital literacy as critical enablers. Earlier ICT-related programs demonstrate promising strides in enhancing digital skills, but systemic challenges, such as inadequate infrastructure, limited vocational opportunities, and an overemphasis on education without corresponding economic diversification, persist.

The role of youth, in particular, is central to this narrative. With appropriate investments in technical education, ICT, and vocational training, the young population can transition from low-skilled labor to knowledge-driven professions. But the critical policy questions remain: How to promote this sector for future generations? How to interplay between 4IR and the country's large population? Or, if the 4IR emphasizes automation and mechanization, what will be the implications for the country's massive labor force? However, at present, most analyses fail to connect these efforts and provide actionable strategies for implementation. Therefore, as a developing country, it would be a challenging road ahead for Bangladesh to become a part of the 4IR. That being said, it is also important to note that prematurely delving into 4IR might lead to immediate adverse consequences, especially for labor-intensive economies like Bangladesh, which primarily depends on the manufacturing sector and does not possess a diversified economy.

5.1 WAYS AND MEANS OF ENGAGING YOUTH: SOME POLICY SUGGESTIONS

Some actionable steps for leveraging the demographic dividend are a critical component of 4IR in Bangladesh's context. To fully realize the benefits of the demographic dividend, Bangladesh must adopt a multi-faceted approach that

includes targeted policies for skill development, technological innovation, and economic diversification. Addressing these gaps can ensure that this one-time opportunity is not wasted, positioning the country as a competitive player in the global 4IR landscape. While the existing literature provides a strong foundation, further research is needed to explore sector-specific strategies and global benchmarks for integrating youth into 4IR-driven economies. The following are some specific suggestions to promote 4IR in Bangladesh.

5.1.1 Structural and Policy-driven

5.1.1.1 Capital Allocation in Infrastructure

To advance, Bangladesh must build foundational infrastructure and prioritize digital literacy. Investing in robust digital infrastructure to ensure widespread access to technology, enabling entrepreneurs to develop and deploy 4IR solutions effectively. Enhancing digital infrastructure, particularly dependable internet access, is essential. Investments in smart manufacturing facilities and technology parks may function as centers for innovation. Developing robust digital infrastructure is fundamental to supporting 4IR technologies like IoT, AI, and automation. Related suggestions include building reliable internet networks and creating innovation hubs equipped with advanced technologies to support industrial productivity.

While considering the infrastructural challenges discussed in the previous chapter, it can be argued that the government is the main stakeholder that can address those problems. No matter how much Bangladesh strategizes, without application, it cannot reap the full benefit of 4IR. Thus, first and foremost, it is important to assess how much bandwidth the country might need for the full application of 4IR so that it can bring every remote corner of the country within network connectivity. The government needs to work to develop its local production capacity. For example, Bangladesh already has its own optical fiber production factory, including the government-run Bangladesh Cable Shilpa Limited (BCSL). All of them produce high-quality cables that can compete in the international market. However, that is not nearly enough to sustain this tech world. The government needs to support these

institutions and increase the number of such institutions that will be able to meet future demands.

Speaking of optical fibers, just installing them would not be enough; they also need to be sustainably maintained and protected. There are often construction works on roads or highways, and excavators often do not notice the fibers installed beneath the ground and blindly hit them. So, it ends up with damaged optical fibers and a country-wide internet disruption, and it happens quite frequently. The government can take steps to ensure adequate protection and maintenance of the optical fibers installed underground by shrouding them with a strong coat of steel, for example. Also, it can take steps to regulate the spectrum prices.

5.1.1.2 Governance and Policy Interventions

In the digitalization area, the ICT division of the government, the Ministry of Commerce, Ministry of Industries can work together and support the private sector. The Ministry of Education will help in terms of building the capacity of the younger population. Other institutions like the Bangladesh Investment Development Authority (BIDA) can facilitate investment in the country, and a2i has different programs for 3D printing, IT, blockchain, and others. These institutions have strategies and policies, but it is important to note that they can create a cluster of policies and initiatives without bringing more clarity to these things. In many cases, the political parties set ambitious targets that are not necessarily easy to meet or attain. So, in this case, the strategy should be pragmatic, focused, and doable. Based on that, they need to set some clear targets, initiatives, and a clear direction.

The government's participation is emphasized in policy formulation, provision of subsidies, and enforcement of regulatory adherence. Since people do not even have the capacity or the level of computational power to have quantum computing and other technologies, they have to rely on other resources. Hence, participants in FGD urged for programs aimed at raising awareness of 4IR and training the workforce

in relevant technologies. Since people cannot avoid the era of new technology, the government must update its policies and work on these issues.

It is also agreed and supported by other experts interviewed that the GoB could play a leading role in engaging young entrepreneurs in the 4IR through several strategic initiatives. GoB can start by creating a concrete national strategy for 4IR that prioritizes youth involvement and outlines strategies to build the necessary skills, infrastructure, and opportunities. Creating centers of excellence where young innovators can collaborate, access resources, and receive mentorship to develop 4IR technologies. They can offer grants, low-interest loans, and tax incentives to startups focusing on 4IR solutions, reducing financial barriers for young entrepreneurs. Also, government-financed startup funds can offer investments in the form of equity, convertible debt, and grants to pre-seed, seed, and growth-stage startups.

5.1.1.3 Following Best Practices

At present, Bangladesh is not conducive to the requirements of the global market. Therefore, the country needs to look at how the market is evolving all over the world. Also, if the country wants to create an educated and skilled labor force, it needs to look at the trends in the world and develop the skills of youth accordingly. Case studies from around its neighbors can be a useful approach to how the countries make a pool of labor experts in the technological field, since Bangladesh also has huge potential in that aspect. In terms of 4IR practice, some Asian countries (India, China, Japan, etc.), in particular, are progressing well, and Bangladesh can adopt those best practices.

Bangladesh can develop clear policies that are critical to incentivizing the adoption of 4IR technologies. Like those countries, the policies need to be aligned with education, employment, and technological objectives. These partnerships can bridge the gap between academia and industry, ensuring that the youth are equipped with skills that match market demands. Global models of integrating youth into 4IR technologies, such as in India or Vietnam, remain underexplored in the context of

Bangladesh. By examining Japan's Society 5.0 effort, for example, Bangladesh may adopt human-centered and technology-driven policies to harmonize economic progress with social development (Fukuyama, 2018).¹⁸² By embracing 4IR, China is also praised for its skilled workforce, education system, and resource management.

Bangladesh can also learn from advanced countries like Germany and the USA, which have led to 4IR adoption. Germany is commended for its advanced waste management systems and technological efficiency. In order to enter the global market, necessary facilities need to be provided, including proper incentives to develop their careers in this field. The USA can be a glaring example in this regard. The government can promote IT startups by funding them through specialized institutions or simply facilitating the process itself. In this way, the youth will feel more inclined to engage in the implementation of 4IR. As remarked by the former Additional Secretary,¹⁸³

“Awareness, training, and demand”—these three are badly needed, and without any of these three components, the youths will neither feel motivated nor be capable of contributing to the development of 4IR in Bangladesh.”

Apart from Asia, African nations can be an example for Bangladesh to follow. It has been observed that drones are being used in Africa to supply medical goods and services in remote areas. Bangladesh has a thriving medical sector, especially when it comes to providing services. So, the government policy should mandate in a way that digitalization or technological incorporation is not just a peripheral concept but is integral to every step that can bring the country a brighter future.

These examples, indeed, highlight areas where Bangladesh could adopt successful models. Besides, international partnerships can facilitate technology transfer and provide insights into best practices for scaling 4IR initiatives. Customizing advanced technologies to suit Bangladesh's context, particularly its resource constraints, can enhance the nation's global competitiveness while fostering youth-driven innovation.

5.1.2 Social

5.1.2.1 Reducing Rural-Urban Divide

In Bangladesh, the youth of rural areas lag in accessing digital technologies. Ensuring equitable access to digital infrastructure, particularly in rural areas, is vital to bridging the urban-rural digital divide and ensuring inclusive participation. Islam et al. (2022) bridge this gap by linking SDG-aligned policies with 4IR applications like IoT and AI, stressing inclusivity and sustainability. This will ultimately enhance youth engagement, which is a cornerstone of demographic dividend utilization. ICT adoption in governance and education, proposing STEM curricula and rural digital learning incentives. Some actionable measures need to be taken to address workforce readiness in various sectors, including industries and service sectors. Besides, special emphasis should also be placed on creating inclusive policies that prioritize marginalized communities, enabling equitable participation in the digital economy.

At present, the youth have very limited opportunities to access 4IR in the country. As mentioned before, whatever opportunities the country has are very urban based, notably centered around major cities like Dhaka or Chattogram. It is almost a pilot basis or very small-scale engagement. What is needed now is a country-wide engagement to eradicate the digital divide. The pedagogy of their education in universities and schools should be mandated in a way where technological advancements and digitalization can be incorporated. To spread 4IR and digital literacy in the entire country. STEM clubs can be created where the youth can learn about science, technology, and robotics.

5.1.2.2 Investing in the Education Sector for Ensuring Digital Literacy

Education reform is central to preparing Bangladesh's youth for the 4IR. By focusing on the reformation process, the government can expand access to vocational and applied training programs, ensuring that young people are equipped

with relevant skills. Transforming the school system is vital to include technical, vocational, and digital literacy training. Emphasizing STEM education at all levels can create a future-ready workforce who are adept at handling advanced technologies. STEM-based curricula and teacher training programs are needed to update the youth. Initiatives emphasizing AI, robotics, and critical thinking competencies will equip the workforce for forthcoming requirements (Bhuiyan et al., 2023).¹⁸⁴ Beyond foundational education, initiatives for upskilling and reskilling are necessary to address the technological disruptions posed by automation. Lifelong learning programs can help youth adapt to continuous advancements, making them resilient in an evolving job market. While these strategies are essential, existing gaps in rural education accessibility and STEM adoption must be prioritized to ensure inclusivity.

Another area that needs to be focused on and reformed is the educational curriculum coupled with online education. In foreign countries, for instance, children are aware of digital gazettes, and digital platforms for education and learning. The curriculum is of an international standard so that they can compete on the global platforms. So, the curriculum must be reformed by integrating 4IR-related topics such as AI, machine learning, data science, and coding. About online education as well as infrastructure setting, Partnership Development Specialist, JAAGO Foundation¹⁸⁵ shared her practical experience that:

"We launched the digital school programme outside Dhaka, realizing the fact that the biggest gap wasn't students' willingness to learn, but it was the absence of qualified teachers willing to relocate. So, we upgraded classrooms into full digital spaces with screens/projectors, internet, microphones, and a remote teaching system, then expanded to more hard-to-reach areas and strengthened blended approaches after the COVID period. Now the next step is to go further with 4IR: AI-enabled learning platforms, real-time student analytics, adaptive content, and even low-cost AR/VR or IoT-supported smart classrooms to personalise lessons for first-generation learners. In fact, quality education doesn't depend on geography anymore; it can scale nationally."

Thus, it is realized that a well-planned infrastructure needs to be developed countrywide for social capital development, and then it will have wider impacts on the community, society, and the country's overall economy.

5.1.2.3 Balancing Gender

Youth can bring a positive social impact by contributing to the technological sector if everyone gets equal opportunity in society. Because of their motivation to drive social changes and their advocacy for equitable access to 4IR benefits, certain segments of society, particularly women, the rural population, and marginalized communities, can play a role in digital transformations.

Youth engagement initiatives should prioritize both men and women, focusing on inclusive development to strengthen societal resilience. Mitigating unemployment risks and promoting gender equality are critical to ensuring the social sustainability of 4IR. Establishing social safety nets and alternative employment opportunities can address labor displacement caused by automation. Including women in technical education and workforce development programs can help bridge gender gaps, maximizing the demographic dividend. Thus, maintaining gender parity is crucial while focusing on providing or democratizing this whole 4IR program, denoting that everyone in society requires it.

5.1.3. *Economic*

5.1.3.1 Industry-Specific Applications

Sector-specific applications of 4IR can provide tangible benefits while creating opportunities for youth involvement. When factories adopt automation, digital production planning, AI-based quality checks, or smart supply-chain systems, productivity goes up and lead time comes down. In healthcare, telemedicine and AI diagnostics can expand access and improve quality, particularly in underserved regions. By linking these industry advancements with vocational training and youth engagement programs, Bangladesh can ensure that its younger population contributes to and benefits from 4IR technologies.

There is a concern that due to automation, the job market will be squeezed. But experts view that the jobs will not disappear; rather, the nature of jobs will change, especially for the youth. As stated by the Research Officer, Ethical Trading Initiative Bangladesh¹⁸⁶,

“If we invest in structured reskilling and upskilling for youth to match those roles, the sector stays globally competitive, and the workforce becomes more productive. And that’s exactly how demographic dividend grows: not just by having a large youth population, but by turning that population into a skilled, future-ready labour force that drives higher value addition and sustained economic growth.

Holistic or integrated policies need to be tailored to resource-constrained economies like Bangladesh. Simultaneously, adopting sector-specific strategies for 4IR integration is a necessity of the time. In this regard, public-private collaborations may potentially mitigate financial issues (Bhuiyan et al., 2020). In industrial sectors, streamlined tax regulations, incentives for the use of advanced technology, and financial support programs for small and medium-sized enterprises help expedite industrial transition. Initiatives need to be taken on ethical data use and infrastructure gaps, advocating for cybersecurity improvements, and skill development in AI and robotics. Emphasizing innovation policies that address inequality and enhance digital infrastructure. Also, simplifying business registration and compliance procedures is helpful to make it easier for startups to operate.

Establishing smart factories can drive automation in key sectors, particularly garments, a major contributor to Bangladesh's economy. However, to integrate youth into this transformation, these ecosystems should include opportunities for skills training and entrepreneurship, enabling younger populations to engage actively in emerging industries. The government has a big role to play in developing infrastructure and enhancing related facilities to create opportunities for the youth for practical implementation.

5.1.3.2 Fostering Innovation in the Industrial Sector

Youth have the power to embrace and drive technological innovations, entrepreneurship in technology, tech, and startups, solve local problems with global tech, and catch the technologies more easily. They are the role models of spreading digital literacy in the country since they can catch the technologies more easily. Although there are some national-level initiatives on 4IR, these are scant. To overcome this, skill development can be done in two ways: first, by identifying existing skill requirements and upscaling them, and second, by reskilling where necessary, transformation is needed into a valuable resource. Conducting proper mapping of the skills that the youth require to consider both national and global opportunities. If Bangladesh can develop skills accordingly, it will create tremendous opportunities. While doing this, Bangladesh must also consider AI disruptions happening worldwide. It needs to identify job sector requirements and analyze where Bangladesh and the global market are heading. Based on that, Bangladesh should focus on developing youth skills to align with these changes. Through this process, AI will create even more opportunities for young people.

In order to keep the youth updated about technology to get into business and global job markets, more preparation is needed countrywide. Currently, there is a rising demand for supporting the innovation sector for youth, especially education and skill development. Youth have an interest in learning new things. In the past decades, the education system was a little backward, and the curriculum was not up to the mark to reach the global market. Thus, blended education that integrates theoretical and practical skills might mitigate the anxiety of unemployment resulting from automation. Vocational programs bridge the gap between traditional education and the evolving demands of the job market. This alignment not only enhances employability but also fosters innovation and adaptability among young professionals. Moreover, a workforce proficient in 4IR-related skills attracts foreign investment and drives economic growth, positioning Bangladesh competitively in the global arena.

The government can also establish innovation hubs and technology parks to encourage collaboration, research, and development among youth. Additionally, policy and regulatory frameworks must be updated to support emerging technologies and address issues such as cybersecurity and data privacy. By building connections between academia, industry, and policymakers, the government can create a seamless ecosystem where young people can transition from learning to contributing to 4IR advancements. Moreover, integrating 4IR-related subjects into educational curricula and providing vocational training to equip youth with the necessary skills.

Promoting R&D tailored to Bangladesh's unique challenges is vital for localizing 4IR technologies. Increased investment in R&D and support for tech-based startups through funding, incubators, and mentorship can stimulate innovative ecosystems. Encouraging youth-led startups can tap into their creativity and entrepreneurial potential, enabling them to contribute directly to Bangladesh's digital transformation. Collaboration between academia, industry, and government can further facilitate these efforts, ensuring a coordinated approach to fostering innovation.

4IR technology is based on problem-solving matters, which drive the young force to the problem-solving education systems. Thus, promoting innovation and entrepreneurship requires funding, mentorships, and networking opportunities. Since the young have very little access to funding opportunities, government-supported skill development initiatives are needed, along with mentorship and networking opportunities. The seniors, like the people who are technically skilled and working in industries like AI, robotics, and computer engineering sectors from the beginning, can also be engaged at a large scale to bring a rapid transformation in this sector. As requested by Co-founder Tetra,¹⁸⁷

"Limited time investment makes the youth suffer, so we must take care of that. At present, we don't have enough to invest in AI research, automation, or quantum

computing. And slow adoption of high-speed internet also hinders the growth of those IT sectors beyond Dhaka or beyond metropolitan cities.”

To get rid of this, Bangladesh needs to develop AI and robotics research centers. The country needs to develop local talents who can bring job projects and more investments here in Bangladesh. Also, the GoB needs to introduce appropriate national AI and IoT policies which should be friendly to IT, SMEs, startups, and youth innovators. The country has also had to ensure cybersecurity and data privacy frameworks.

5.1.3.3 Increasing Tech-driven Entrepreneurship

The rise of entrepreneurial initiatives among young people also presents a great opportunity. By fostering startups through incubators, funding, and mentorship, the country can encourage innovative, youth-led solutions to pressing challenges. Expanding access to tech startup loans for young people and providing research funding from banks, public institutions, and private organizations can significantly boost young people's involvement in the 4IR. Loans and grants dedicated to innovation and technology-driven projects can encourage them to launch startups and conduct research in cutting-edge areas. These financial initiatives, combined with streamlined processes and mentorship programs, can create fertile ground for young people to explore and implement innovative ideas. Bangladesh's increasing integration into global tech networks and the inflow of foreign investment provide avenues for exposure to international markets and technologies. Combined with the government's focus on digitalization and youth empowerment, these opportunities can help young people take the lead in driving Bangladesh's 4IR progress.

Another thing is that a fostering and supportive environment is needed for remote work and freelancing to thrive. Bangladesh already has a strong, vibrant freelancing community who are key resource to maximize 4IR in Bangladesh. The country, thus, has to leverage them to use the benefits of 4IR. Looking at the country's growing tech industry, it is seen that this has the potential to drive noteworthy changes. Bangladesh has skilled freelancers and has on some level, government

support as well. Initiatives like high-tech parks or business programs have already aimed at boosting IT growth. If the youth can come up with innovative ideas and get the necessary policy support, Bangladesh can tap into the dividends of 4IR. This is the foundational area where Bangladesh will be able to start leveraging the benefits of 4IR. Without such effort, it would be an arduous task for the country to sustain in a technology-oriented job market.

5.1.3.4 Increasing Foreign Investment and Assistance in Implementing 4IR

Foreign investment and assistance are essential for Bangladesh to effectively implement the 4IR. Such external support can provide the necessary capital, advanced technologies, and expertise to accelerate the country's digital transformation. However, it is crucial to ensure that these investments are managed and budgeted properly, free from corruption, to maximize their impact. Implementing integrated policies that promote transparency, and accountability will help create a conducive environment for sustainable development. The involvement of the private sector is pertinent to leading these initiatives and trying to bring in foreign investment, and foreign collaboration, so that it can have that bridge of the kind of knowledge, as well as investment and infrastructure.

Foreign investment is a major requirement for being able to implement 4IR. All those infrastructural requirements would be unbelievably expensive. Even with the private sector involved, the country will not be able to raise the necessary funds for it, and for this, this is the area where the country will need investments like FDI or joint ventures. The country can also dedicate a special economic zone, like Silicon Valley in the USA, for IT research, production, training, development, and export to further facilitate the process. It can also attract investment. But obviously, the government will have to facilitate that process.

5.1.4 Technical and Skill-oriented

5.1.4.1 Language Proficiency

Language, indeed, holds significant importance for receiving and understanding 4IR technologies. It is also essential to examine the global languages that are driving technological advancement. English is the most prevalent language, followed by Chinese and various other languages that people can use to assist individuals in learning. About increasing English language skills, the Data Analyst remarks,¹⁸⁸

“English serves as the global lingua franca, facilitating access to a vast array of scientific literature, technological resources, and international collaboration opportunities. A strong grasp of the language will also help them translate local innovations and take them to the global arena.”

The English language is indeed significant since Bangladesh desires to enter an era when services or applications might facilitate language translation and enhance communication. Regarding the English language, for a long time, the youth have been suffering language barriers in Bangladesh. However, if there is a deficiency of competence among the youth, they will lag in global competition. So, prioritizing the training while concurrently developing other languages such as English or Chinese is crucial.

In many cases, young people lack proper communication strategies to bring in projects or enter into job market because of a lack of communication skills. Hence, the country needs to focus on leveraging the existing networks and training the youth in communication strategy. Beyond English, the government has to think of other languages to compete with the global market. There should be some training sessions on how the youth can express themselves properly, how to present themselves in a wider field, how to communicate with others, and how to convince investors and employers.

5.1.4.2 Vocational Training

Vocational training in Bangladesh's context is crucial, considering the evolving global market, apart from the knowledge stemming from traditional theoretical knowledge. The roles they are undertaking must be adapted to align with the new curriculum and the emerging technologies available in the market. Bangladesh should also broaden the scope of vocational training. The focus should not be solely on traditional skills such as typing and computer usage; rather, it is equally important to consider how to effectively navigate the internet and various software applications, as well as how these tools are evolving and how the curriculum is being adjusted accordingly. Providing STEM as vocational training needs to be focused on creating a labor pool for masters in programming, and it is not just limited to university graduates or top-tier universities.

In fact, technical and vocational training is based on the interests and requirements of the youth, like learning coding, web development, and cybersecurity issues. This will also help them to earn foreign income, like remittance for the countries, and this will also increase the horizon of job opportunities. Technical and vocational training needs to be increased in rural areas so that the youth can learn about technological use on a practical basis. As informed by the Co-founder, Tetra,¹⁸⁹

“About vocational training, I truly believe that this can help, and we have a good network of vocational institutions countrywide, but we have to build a curriculum and leverage infrastructures to train our youth in the skills regarding 4IR”.

It is also essential to rejuvenate and renew the entire curriculum of existing programs of vocational training centers, ensuring that students pursuing diploma courses or technical certificates are equipped with the most advanced technology available in their respective sectors. Additionally, the country must have a robust framework for traditional vocational training that can be expanded into other categories.

5.1.4.3 Workforce Advancement

Rescaling the workforce is an important step for Bangladesh for rapid automation and technological advancement since the expansion of 4IR will require workers or transition from traditional jobs to more technology-driven roles. As economic and infrastructure disparities and urban-rural deviation are wide, energy supply and access to the internet need to be ensured, which are mainly confined to Dhaka and Chittagong, and some other municipalities.

For increasing the skills of young people, capacity building is important. For this, proper infrastructure and economic support are needed. Since access to capital is a problem because of limited funding opportunities, especially for innovation and start-ups, investment from both the private and public sectors is crucial. Since they are using Facebook and other social platforms, digital literacy and awareness ensure proper usage of technologies in society. As remarked by an academic,¹⁹⁰

“If a robot cleans my house and supplies the food, I won’t feel comfortable. Because I don’t know literally how to use those things. If technology becomes more widespread, acceptance is also important to avoid job loss and overall social disruption. So, there should be more awareness campaigns and education about 4IR technologies in our society.”

Since 4IR requires specialized skills, conventional education might not be enough to cover it. That is why it can be suggested that the government should consider establishing a specialized institution to help young people develop their skills for the 4IR. Vocational training is necessary for the development of 4IR and for the young generation. Once 4IR is implemented, the country might potentially see a large increase in unemployment among the low-skilled labor force since the production process will be entirely mechanized. Thus, the country will also need to provide the low-skilled labor force with adequate technical and vocational training to be able to operate these processes.

It needs to be understood that Bangladesh is on the trajectory of development for 4IR. So, the country has to know how far technology has evolved globally, where it started, and how far it can go. Especially, when it comes to languages, there must be a comprehensive mechanism where students get to learn proper languages that help them to understand the concepts of 4IR and develop their skills in that direction. English language proficiency, in this aspect, can play a vital role because, by design or default, it is a universal language in which most of the information is communicated. So, the youth need to have a good command over it so that they are able to absorb the information and implement their ideas.

5.1.5 Sector Specific Role

5.1.5.1 Private Sector

Youth development is presented as a cornerstone for leveraging 4IR, with a call to focus on skill-building among young entrepreneurs. The private sector, in this aspect, is identified as a strong stakeholder in skill development and job creation, requiring collaboration with government initiatives. Participants interviewed and during FGD discussions with the young entrepreneurs stressed the need for better connectivity between young entrepreneurs and global markets. For this, certain initiatives should be given the utmost importance. First and foremost, big industries and companies can offer internships, apprenticeships, and entry-level positions tailored to 4IR-related skills, giving young people practical exposure to emerging technologies like AI, robotics, and data analytics.

Second, businesses can also invest in collaborations with educational institutions to design curriculum updates, sponsor research initiatives, and provide mentorship programs that prepare students for industry needs. By setting up training centers, innovation hubs, and accelerator programs, the private sector can foster entrepreneurship and encourage youth to develop tech-driven solutions to local and global challenges. Finally, the private sector can contribute by funding scholarships, grants, and startup loans for young innovators, enabling them to

launch their own ventures or pursue advanced studies in 4IR-related fields. Lastly, private enterprises can leverage their global networks to provide young people with exposure to international markets, trends, and best practices, positioning them to excel in a competitive 4IR landscape.

Third, the private sector is at the core and center of how businesses are evolving. In this regard, the government can help with the policy reforms and mandates, and the private sector can help the government by providing funds and facilities that the latter can leverage to help the youth in getting the skills and the knowledge to be ready in this volatile labor market, where technological skill plays a huge role. The private sector can partner with the government to create opportunities for the youth. As added by Former Human Resources Personnel, IUCN,¹⁹¹

“If the private sector partners up with the government, they are not only helping create a steady flow of labor force for their companies but also getting a competitive edge because they also need to survive in the market. And, if they don't evolve with the labor force, they cannot sustain themselves in the long run. So, for their own survival, they should partner up with the government. They can do it through different schemes and programs (for example, giving funds to different youth-led ventures who are working in this field).”

Fourth, the private sector can leverage different competitions like hackathons and robotics competitions so that interest can be created in the market because the market is only going to shift when there is an interest or a demand for it. This can be created through the government mandate and the private sector interests.

Finally, at present, most of the IT graduates are employed in the private sector. They are the only incentive providers in the current IT market. They can provide internships or courses for skill development. They can also employ skilled students from the final year or graduate students before they finish their studies, like they do in Japan, to entice more students to develop skills in this field. They can also conduct research and employ students as RAs to help them build their portfolios.

Basically, any investment they make to cultivate young minds would not be a loss project; when it comes to IT, change is an unchanging phenomenon. The market for the tech field is constantly in demand. So, the private sector can use the young, skilled workforce to make the best use of that market demand. Also, if the government can establish a specialized framework for developing the 4IR workforce, it can collaborate with the private sector to send these youths for hands-on industrial experiences.

Private firms consistently remain informed about worldwide best practices to maintain a competitive edge and lead within their respective industries while effectively conducting their operations. Private sectors, such as corporations, may help with this initiative by sharing their expertise and experience with young people. They may provide opportunities for young individuals. They may be at their offices or visiting campuses to share their expertise and successful examples. Facilitating access to information for adolescents is crucial.

Private groups may assist youngsters in adapting to these changes. In my view, private groups may serve as effective advocates for the government, since they often demonstrate more agility and initiative compared to the government, which can be hindered by bureaucratic processes. Private initiatives may serve as effective advocates, demonstrating how the young in Bangladesh can prepare for future global developments. If both public and private partnerships are effective, they will be advantageous for the government, Bangladesh, and the global community.

5.1.5.2 NGOs and Business Sector

Youth engagement in the NGO sector is needed to get into the world of 4IR. It is noted that although partnership has to be with global tech and global companies (since technology is invented mostly by the private sector or companies), it is the NGO sector, through which the youth can be accommodated further. Aside from NGOs, participants in FGDs emphasize the need for the business sector to actively

engage in skill development, research, and innovation. They propose the establishment of entrepreneurial ecosystems and the augmentation of investments in technology-driven sectors. Cooperation between governmental and private entities is considered crucial for addressing systemic difficulties.

Currently, brain drain is another problem that Bangladesh is facing. Young people lack the ability to give their full potential at the moment, and the brain drain is the result of this failure. Bangladesh can address these gaps by integrating large-scale STEM-focused programs and fostering entrepreneurship. International collaboration and technology transfer can further enable localized solutions. While progress in specific sectors like garments and agriculture shows promise, a comprehensive, youth-centered strategy remains critical to realizing the full potential of 4IR.

Bangladesh needs to create market demand and incentives for these brains to consider staying in Bangladesh. The business sector can come in by creating new opportunities for young entrepreneurs. Simultaneously, GoB must first build up adequate infrastructure for 4IR, create a skilled workforce to sustain 4IR, and finally, create enough market demand and incentives comparable to other developed countries if the country wants to keep the youths in secure and lucrative job markets. If the country can make it possible, the problem of brain drain will also be reduced considerably.

5.1.5.3 IT Sector

In the country, there is a huge scope for improvement in the IT sector if favorable conditions for this sector can be created. In this aspect, the government can fix certain mandates, such as tax cuts or giving more subsidies to get experts from outside to lead certain programs. In this way, the IT sector can get experts from outside who are going to set up and explain some of the requirements and the global

standards. In fact, there is a huge scope of work in this field where the government can play by observing trends and market needs.

It needs to be mentioned here that Bangladesh's information and IT sectors have made significant strides in recent years, contributing to the nation's digital transformation. However, there are the following scopes of improvements: To address these issues, it is essential to streamline administrative processes, reduce red tape, and enhance transparency in government dealings. Implementing e-governance solutions can facilitate more efficient interactions between businesses and regulatory bodies, thereby fostering a more conducive environment for IT enterprises. Additionally, updating legal frameworks to accommodate emerging technologies and business models is vital. This includes revising laws related to digital transactions, intellectual property rights, and data protection to reflect the current technological landscape.

While formulating policies, it needs to be acknowledged that the IT sector consists of both the private and the public sectors. Essentially, two ministries are working on IT: The ICT Division and the Post and Telecommunication Division, and both of them are responsible for the IT industry in Bangladesh. The Post & Telecom Division is responsible for dealing with the infrastructural part of the sector. The ICT division, on the other hand, deals with things like planning, strategizing, and the implementation of IT policies and such. However, there are occasional internal conflicts between the two divisions over their jurisdictions, so the process does not often go smoothly. It would be much easier to bypass the bureaucratic obstructions by merging both ministries. About these two ministers, along with the IT sector, the Former Additional Secretary opined,¹⁹²

"A computer cannot run without either the hardware or the software. These two ministries are in a similar kind of relationship, like computer hardware devoid of its software. I think it is very important to make sure the government creates a conducive environment for the IT sector to thrive first, otherwise, people will keep

hearing complaints from the stakeholders in the IT sector regarding how there are “bureaucratic obstructions” hampering their progress”.

In the future, the youth will greatly contribute to developing the IT sector by starting their own projects. With adequate support, they might even be able to provide services that would be difficult for the government alone to provide. They can also facilitate imports and exports. Bangladesh’s IT market is relatively small, so the competition is also small. It is not enough to be called a monopoly, perhaps, but it is not very competitive either. Successful entrepreneurs can increase market competition and ensure the IT industry thrives further.

5.1.5.4 Public-Private Partnerships

Creating stronger public-private partnerships is key to providing resources, funding, and mentorship for young innovators and entrepreneurs. Arranging open enrollment opportunities for training programs ensures that more young people, regardless of background, have access to skill-building initiatives. Moreover, fostering greater collaboration between engineering universities and policy-oriented universities or social science departments can help bridge the gap between technical expertise and policymaking. Promoting interactions between public and private universities can also enhance resource-sharing, innovation, and diverse perspectives in preparing the youth for 4IR. Introducing 4IR-related topics in high school curricula, along with more vocational and applied courses at both high schools and universities, can help students build practical knowledge early on.

It is observed that 4IR should be related to a country’s ecology and environmental protection, and the private sector can play an active role in these areas. Keeping these in mind, the private sector can unlock the potential of Bangladesh’s youth and drive the country’s digital transformation forward. As remarked by an expert from Action Aid,¹⁹³

“We need to incentivize the private sector and innovation. We also need to think about how we can develop the ecosystem in a public-private partnership. Otherwise, if we take the ecosystem only to the government, it will not work in the

long run. Because technology, along with the system, changes every year. Accordingly, we need to work together to go to the next level.”

Bangladesh needs to incentivize the private sector to ensure further innovation. The country needs to think about how it can develop the ecosystem in a public-private partnership. Otherwise, if the country takes the ecosystem only into the government, it will not work. Because technology changes every year. The system changes every year. Therefore, Bangladesh needs to move to the public-private partnership from an inefficient place.

5.1.4.3 Remote Collaboration

It is a concern that over-dependence on 4IR technologies will harm the job market since jobs will be displaced in the coming decades. In that case, Bangladesh has to think in advance about the people who will be under the trap of job displacement and who will be able to retain jobs, including the re-skilling of the people. In fact, 4IR is lifelong learning, and it is a continuous process. While thinking about youth, digital literacy comes into understanding and realizing the full potential of 4IR.

Leveraging technology can transform this challenge into an opportunity. By facilitating remote collaboration, Bangladeshi experts residing abroad can contribute significantly to the nation's 4IR initiatives. Universities can engage these professionals to offer specialized courses, either through short-term visits or virtual classrooms, enriching the academic environment with global perspectives. Additionally, research centers can involve expatriate experts in managing and organizing projects remotely, ensuring their skills and knowledge benefit local developments. Such inclusive strategies not only mitigate the effects of brain drain but also integrate a diverse range of expertise into Bangladesh's technological advancement.

5.1.6 Psychological

5.1.6.1 Changing Mindset

In Bangladesh, automation has already been happening for the last five or seven years. There will be job losses for blue-collar workers and also for white-collar workers. To some extent, there will be job losses for white-collar workers as well. And onshoring might happen after the next five to ten years. Because the country has a lot of graduates who are coming out of these government colleges. But most of them are unemployed. For example, if a person graduates from college, he might think himself inappropriate for a factory because of his higher degree. As discussed by the Director, Finance, Strategy and Consulting Services, Light Castle Partners,¹⁹⁴

“I think that is a problem that we have. We don't need too many graduates in colleges. Because they are not essentially creating a skilled population. They are just dishing out certificates.”

Many of the Bangladeshis who graduated from top-notch national and international universities are working in different labs. If the country can bring in and use their expertise, it will be a great help for the country.

5.2 Last Thought: 4IR and Vision for the Future

By and large, 4IR is characterized by an unprecedented fusion of technologies, blurring the lines between the physical, digital, and biological spheres. Bangladesh, with its large youth population and emerging digital economy, stands at a crucial juncture to leverage this transformation. The country's demographic dividend offers a significant opportunity to harness human capital and accelerate economic growth. However, there are challenges to overcome in terms of skills development, technological adaptation, and creating a sustainable ecosystem that promotes innovation. Bangladesh's youth population, which accounts for more than one-third of the total population, represents a critical mass of human capital. With strategic

investments in education, training, and technology, this demographic segment can be transformed into a driving force for economic and social change.

Currently, Bangladesh faces challenges such as inadequate access to quality education, a lack of digital literacy, skills mismatches, and limited research and development capacity. Meanwhile, global trends indicate that countries failing to adapt to 4IR risk being left behind in terms of competitiveness and productivity. The 4IR has vast implications for Bangladesh's growth trajectory, influencing sectors such as manufacturing, agriculture, education, health, and finance. By developing an empowered workforce, Bangladesh can attract investments, enhance innovation, and achieve sustainable economic growth. With a targeted strategy, the country can achieve its vision, transitioning into an upper-middle-income economy. Hence, Bangladesh's demographic dividend presents an unparalleled opportunity to envision and achieve a 4IR-driven future. By investing in its youth, building strategic partnerships, and creating an enabling environment for technological transformation, the country can pave the way for inclusive, sustainable, and competitive growth. The time to act is now, as Bangladesh moves to position itself as a regional leader in innovation and development in the era of the 4IR.

Needless to say, Bangladesh's path to 4IR adoption is marked by promising initiatives and significant hurdles. Addressing challenges like the digital divide, labor displacement, and inadequate skill development requires cohesive policy reforms. Leveraging its young population and demographic dividend through inclusive education, innovation ecosystems, and targeted investments can transform these challenges into opportunities, ensuring sustainable progress in the Fourth Industrial Revolution.

Although 4IR technology is still in its infancy, it goes without saying that there is a significant possibility in Bangladesh's 4IR. The demographic dividend is seen as a crucial opportunity, with expectations that appropriate policies and young involvement would facilitate substantial advancement in Bangladesh over the next

10-15 years. To fully harness the 4IR and ensure sustainable development, Bangladesh must adopt a multifaceted approach that focuses on infrastructure, education, governance, and collaboration. A cooperative strategy including the government, commercial sector, and youth only can tackle the complex issues of the 4IR of the country and overall sustainable development, contingent upon the prioritization of key investments, policy changes, and skill enhancement programs. These strategies can bridge existing gaps, promote youth inclusion, and leverage the country's demographic dividend. To unlock the potential of 4IR, Bangladesh must align government, industry, and academia in a coordinated effort that leverages its demographic dividend. Prioritizing youth inclusion through education, entrepreneurship, and policy reforms is critical to achieving this transformation. By addressing current challenges and focusing on inclusive growth, Bangladesh can emerge as a model for sustainable development in the Fourth Industrial Revolution.

Annex 1:

Check Lists/Interview Schedule:

a. Background Questions:

Name of the Expert:

Designation:

Cell Phone:

Interviewer's Name:

Date & Time of the Interview:

1. Can you pls share your views about the demographic dividend in Bangladesh?
2. What is the condition of the youth now? Do you find any differences between the youth of rural and urban areas?
3. In your opinion, how can the youth contribute to Bangladesh's transition to a smarter nation?
4. In that case, how can we engage them in different development sectors?
5. Would you please share your ideas with us about 4IR?
6. What is your opinion/views on the young people of Bangladesh?
7. What challenges might Bangladesh face in implementing 4IR?
8. How would the young people/young generation contribute/assist in realizing 4IR?
9. How can we engage/involve the young people of Bangladesh in implementing 4IR?
10. What opportunities do we have to get the young people engaged in implementing 4IR in Bangladesh?
11. What are the probable challenges we might face in getting the young people involved in implementing 4IR?
12. What role the Government of Bangladesh might play in getting the young people involved in implementing 4IR?

13. What role does the private sector of Bangladesh play in getting the young people involved in implementing 4IR?
14. In order to realize 4IR, the information and IT sector would play a pivotal role. Do you think the current state of our information and IT sector can provide a conducive platform to implement 4IR?
15. What roles might the young people of Bangladesh play in developing the information and IT sector?
16. What is the importance of learning English and science in implementing 4IR?
17. What is the importance of vocational education for Bangladesh's young people to implement 4IR?
18. What role might young entrepreneurs play in implementing 4IR?
19. What initiatives does the Government of Bangladesh take to get the young entrepreneurs involved in the implementation of 4IR?
20. Do you think brain drain would be an obstacle to the implementation of 4IR in Bangladesh?
21. Do you think we need foreign investment/assistance in implementing 4IR?

Annex 2: List of KIIs Interviewed for This Study

No.	Designation
1.	Former Additional Secretary, Post & Telecommunication Division; Head of Telecom Wing; Former Director-General, Department of Telecommunication (DoT)
2.	Head (Future of Education), a2i
3.	Programme Associate, a2i
4.	Edtech Program Professional, Partnership & Project Management, a2i
5.	Youth Led, ActionAid
6.	Lecturer, Noakhali Institute of Science and Technology
7.	Co-founder, School of Entrepreneurship Development and Bikash
8.	Founder and Co-President, iEntreprene
9.	Co-founder, Tetra, BUET, and IBA Master's Graduate
10.	Entrepreneur-Self-Employed in the Agri-fisheries Sector
11.	Data Analyst, Public Management of Technology – Syracuse University, New York, USA
12.	CEO, Be Digital Today
13.	Co-founder, Youth Opportunities
14.	Director, Finance, Strategy and Consulting Services, Light Castle Partners
15.	Former Human Resources Personnel, IUCN Asia Regional Office
16.	Professor, Department of Economics, DU
17.	Professor, Department of Development Studies, DU
18.	L&D Specialist, BYLC
19.	Programme Manager, JAAGO Foundation
20.	Partnership Development Specialist, Private Sector Engagement, JAAGO Foundation
21.	Co-Founder and CEO IniLabs Bangladesh
22.	Research Officer, Ethical Trading Initiatives
23.	Trainer and 5 th Year Medical Student, Dhaka Medical College

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