Exploring Motivating Factors in the Adoption of AI Technologies for Green Economy

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Abstract - Environmental sustainability and climatic stability require human efforts. AI is among the frontier technologies for green economy. The purpose of this study is to identify and rate the factors that enable the adoption of AI technologies meant to contribute to green economy. The study involves factor exploration and use of analytical hierarchy process to evaluate the factors using a purposive sample of AI technology service experts. The findings reveal the capacity of the organizations to leverage such technologies as the most significant factor while perceptions of its ease of use and effectiveness as the least relevant factors. The results have both academic and practical implications.

Keywords - AI technologies, green economy, AHP, adoption of AI, Artificial Intelligence, sustainability

1. INTRODUCTION

Climate change and environmental sustainability are among the major existing and future global challenges. The United Nations' sustainable development goals prompt the nations to focus on net-zero transition and to sustain the 1.5 degree Celsius threshold (UN, 2024; UNCC, 2024), for slowing down the calamitous changes and irreversible damage to the planet. The latest report of United Nations Trade and Development designates artificial intelligence (AI) among the frontier technologies that contribute to green economies (UNCTAD, 2023a, 2023b; UNEP, 2024). However, developing nations are unable to leverage the benefits of these technologies for the want of policy-driven and market-driven impetuses to drive the transition (UNCTAD, 2023a; World Economic Forum, 2023). India is pioneering at a global rank 4 in research and development of green technologies, yet it is far behind, at 46ᵗʰ rank in readiness for green technology adoption (Fig 1) (UNCTAD, 2023a). It is therefore, pertinent to understand what factors promote the use of such technologies for an environmentally sustainable economic growth of a nation.

In the next section (Section 2), we discuss the literature reviewed to explore the concept of green economy and green technologies, AI's role in green economy, and the industrial sectors where AI has been found to leave an indelible progressive impression and enable sustainable economic outcome. We identify the research gaps, and define the objectives of our research at the end of the section 2. In section 3, we describe our research methodology to achieve the defined objectives. In section 4, we present the findings in form of the explored factors that motivate the adoption of AI for sustainable environment. Later in this section, we also show the results of the analysis that we performed to capture the perspective of a sample of Indian AI tech-service company leaders towards these factors and their relative order of relevance. We also illustrate the verification of our findings through consistency checks in section 4. Section 5 concludes the article with the future scope of our research.

2. REVIEW OF LITERATURE

Sustainability of environmental resources and economic growth are simultaneous global concerns and at national level. Balancing of both the goals is scoped in the concept of green economy. Several definitions of green economy are available with socio-economic and environmental dimensions along with practical implementation of the conceptual paradigm (Loiseau et al., 2016).

Green technology, energy efficiency, biodiversity, and circular economy are among the methods to decouple the economic development from rising carbon footprint (Merino-Saum et al., 2020). Approaches and frameworks to assess and measure the implications of green economy are also discussed and used in academic literature (Georgeson et al., 2017; Loiseau et al., 2016; Merino-Saum et al., 2020). The innovations in technologies that create minimum impact on the environment while increasing the productivity are referred as green technologies (Jänicke, 2008; Merino-Saum et al., 2020). Green technologies have a substantial influence on the green economy (Wani et al., 2024). In terms of the ICT infrastructure, research and development, skills, industry and finance, these frontier technologies may be variably used by the industry to mitigate negative effect on the environment and climate (UNCTAD, 2023a).

Integration of AI with green technologies leads to better performance of the organizations towards environmental innovation (Khunakornbodintr, 2024; Yin et al., 2023). AI technologies automate routine tasks, discover new patterns and enable informed decision-making. These functions can allow an economic boost as well as provide continuous monitoring and control of activities affecting natural systems. They are expected to bring the emissions down by 4.8% and enhancement the gross domestic product by 5.1% (Herweijer et al., 2019). There are several sectors where AI plays a crucial role for environment and resource sustainability. Green innovation (Wang et al., 2023), green construction (Khan et al., 2023; Xiang et al., 2022), green infrastructure (Shaamala et al., 2024), green manufacturing, green supply chains (Rashid et al., 2024), green communication (Srivastava et al., 2021), and renewable power sources and energy (Alassery et al., 2022; Zhou et al., 2024) are some of the sectors where that AI creates an impact. However, enterp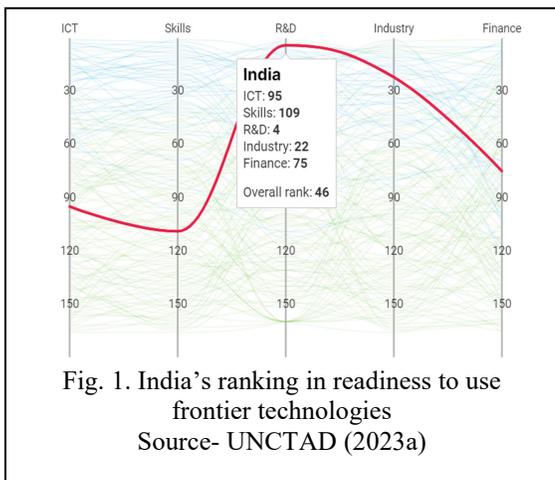rises targeting environmental and social benefits may hold heterogeneous capacities, specializations, risk attitudes and resources. Ample literature is available to delve into the applications and implications of AI on green economy (Zhao et al., 2022) and to justify AI adoption. Yet limited body of synthesized knowledge is available that discusses the factors motivating the adoption of AI for green economy. Therefore, this research aims to (O1) explore these factors, and then (O2) find relative weightage of these factors in influencing AI technology integration for improving social, economic and environmental impact.

Fig. 1. India's ranking in readiness to use frontier technologies
Source- UNCTAD (2023a)

3. METHODOLOGY

The first objective of this study is completed using a thematic literature review for the exploration of factors (Snyder, 2019). Thematic literature review included using the keywords ("Green AI" or "AI for green economy" or "frontier Technologies" or "artificial intelligence") and ("green economy" or "green growth") and ("motivating factors" or "determinants" or "influencing factors" or "factors") and ("technology acceptance" or "technology adoption"). We searched Scopus, Google Scholar and Web of Science databases. We used only peer-reviewed journal articles, or international organizations' reports or working papers that were in English language for our analysis. In the first round of analysis, we filtered the search results by

reviewing the title and abstract of the search results to match our objective O1. We then iterated the filtration process based on our inclusion criteria to get the final set of research documents to explore the factors. We determined seven factors through the literature synthesis.

For research objective O2, we deployed Analytic Hierarchy Process (AHP) method (Munier & Hontoria, 2021). We recruited a purposive sample of 13 senior managers with a minimum experience of five years in a strategic role in AI technologies and IT services firms to answer our questionnaire for pairwise comparisons of the factors identified as outcomes of O1. We used snowball sampling method to reach the individuals with the requisite profile. A small sample size is often used in the AHP method to reduce inconsistencies and complexity of pair-wise comparisons of the judgments. We also performed a consistency check of our findings to ensure coherence in the opinions of the experts.

4. RESULTS & ANALYSIS

The thematic review of the literature indicated several factors that affect the adoption of a technology. However, seven factors were identified that enable AI technologies to be adopted by the industry, governments and the society, and especially for the purpose of promoting green economy. Table 1 enlists these factors, their description, and their sources. These factors are the capacity to leverage AI technologies by the industry, adoption of complementary sector-specific technologies, upskilling and reskilling, policy attention, targeted investment in green AI innovations, perception for effectiveness of AI in reducing deterioration of environment and climate change, and perceived ease of use.

TABLE I.   FACTORS MOTIVATING AI ADOPTION FOR GREEN ECONOMY

S.No.	Factor	Factor Description	Source
F1.	Capacity to leverage AI technologies by the industry	The ability to utilize the AI technologies and tools for optimization of resources.	(Lada et al., 2023; Maroufkhani et al., 2020)
F2.	Adoption of complementary sector-specific technologies	Using technologies to allow use of AI tools for boosting the objective of environment and resource sustainability.	(Herweijer et al., 2019; Khan et al., 2023)
F3.	Upskilling and reskilling	Building capacity to develop AI technologies for green economy.	(Herweijer et al., 2019; Maroufkhani et al., 2020; UNEP, 2024)
F4.	Policy attention	Government intervention and support to develop and push AI adoption for green economy.	(Lada et al., 2023; UNEP, 2024)
F5.	Targeted investment in green AI innovations	Financial and strategic investments driven to allow R&D and innovations in AI technologies for green economy.	(UNEP, 2024; Yin et al., 2023)
F6.	Perception for effectiveness of AI in reducing deterioration of environment and climate change	Optimistic perceptions that AI can effectively prevent or reduce damage to nature and climate.	(Dorhetso & Quarshie, 2023; Herweijer et al., 2019)
F7.	Perceived ease of use	Positive perception that AI technologies are easy to use.	(Dorhetso & Quarshie, 2023; Kelly et al., 2023)

These factors are also consistent with some of the UNDC recommendations for climate action at the policy level and include financial, technical and capacity building support by the governments for sustaining the future (UNCC, 2023a). The relative weightage of these factors influencing adoption of AI technologies for green economy was determined by computing pairwise comparison matrix, normalized matrix and priority vector using the responses of the experts in AI technologies design and strategy (Tables II and III). The results based on consensus of the responses revealed that the capacity to use AI tools is considered to be the most important factor enabling AI adoption for green economy, with 32% weightage. This is followed by adopting complementary technologies (24%), skill development in AI (15%), policy focus (11%), targeted investment (8%), and optimistic perception towards AI as being effective (6%) and easy to use (5%). The principal Eigen value λ_{max} derived from the matrices and priority vector is 7.724. The consistency ratio of 0.09 was computed and was found to be within the acceptable threshold of 0.1. Hence the consistency among the factor comparisons is verified.

TABLE II.   PAIRWISE COMPARISON MATRIX

Factor	F1	F2	F3	F4	F5	F6	F7
F1	1.0000	3.3316	3.8034	3.7179	3.0855	4.2821	3.1265
F2	0.3002	1.0000	4.0281	4.0085	4.6410	3.5289	2.1726
F3	0.2629	0.2483	1.0000	2.9145	1.4066	4.3187	3.7265
F4	0.2690	0.2495	0.3431	1.0000	3.4923	2.0476	2.0247
F5	0.3241	0.2155	0.4155	0.2863	1.0000	2.3590	2.0769
F6	0.2335	0.2834	0.2316	0.2471	0.2977	1.0000	2.3707
F7	0.3198	0.4603	0.2116	0.4939	0.2453	0.2967	1.0000

TABLE III.   NORMALIZED MATRIX AND PRIORITY VECTOR

Factor	F1	F2	F3	F4	F5	F6	F7	Priority Vector
F1	0.369	0.576	0.379	0.293	0.218	0.240	0.190	0.324
F2	0.111	0.173	0.401	0.316	0.328	0.198	0.132	0.237
F3	0.097	0.043	0.100	0.230	0.099	0.242	0.226	0.148
F4	0.099	0.043	0.034	0.079	0.246	0.115	0.123	0.106
F5	0.120	0.037	0.041	0.023	0.071	0.132	0.126	0.079
F6	0.086	0.049	0.023	0.020	0.021	0.056	0.144	0.057
F7	0.118	0.080	0.021	0.039	0.017	0.017	0.061	0.050

The results have significant theoretical and practical implications. The researchers may assess the findings in different contexts where AI technologies are foreseen as a prospective solution intended to reduce carbon footprints and encourage resource optimization. Likewise, the policymakers and the industry leaders as AI service providers and service users looking towards a sustainable future of their organizations and the society may prioritize their efforts to leverage these factors. The prioritized actions will stimulate an increased demand for the AI-driven green technologies.

5.   FUTURE SCOPE OF THE STUDY

AI technologies have already pervaded in several areas. However, adoption of green technologies is an area which is not widely implemented. Thus, deeper research into the sector-wise and industry-specific analysis of the motivating factors for adopting AI technologies is a highly relevant area of research.

Additionally, the interaction of the motivating factors with the barriers in the adoption of AI technologies such as over-consumption of resources to run AI data centers may also be explored by the researchers.

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