ARTIFICIAL INTELLIGENCE, SUSTAINABILITY, AND GLOBAL POLITICAL ECONOMY

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Ruba Soundar

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PREFACE

Artificial Intelligence, Sustainability, and Global Political Economy brings together a collection of scholarly contributions that examine the intersections between technological transformation, environmental sustainability, and global economic structures. In recent years, artificial intelligence has emerged as a powerful force reshaping production systems, policy frameworks, and international economic relations.

The chapters in this volume explore key themes such as the role of artificial intelligence in promoting environmental sustainability, the impact of digital platforms on economic participation and market access, and the broader implications of intelligent systems within national and global political economies. These contributions highlight how technological innovation can both address and intensify existing inequalities, depending on how it is developed and implemented.

By adopting an interdisciplinary perspective, this volume integrates insights from political economy, development studies, and technology studies. It offers a comprehensive understanding of how artificial intelligence interacts with issues of sustainability, governance, and economic development in different regional contexts.

It is hoped that this book will serve as a valuable resource for researchers, students, and practitioners interested in artificial intelligence, sustainability, and global economic systems, while encouraging further critical engagement with the challenges and opportunities presented by digital transformation.

Editorial Team

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CHAPTER 1
ARTIFICIAL INTELLIGENCE AND ENVIRONMENTAL SUSTAINABILITY IN INTERNATIONAL POLITICAL ECONOMY: IMPLICATIONS FOR NIGERIA

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INTRODUCTION

Background to the Study

Environmental sustainability is becoming a critical global concern as Nation of the World grapple with the accelerating impacts of climate change, biodiversity loss, pollution, and resource depletion. These Environmental problems have intensified debates on how technological innovation can support sustainable development pathways. Artificial Intelligence (AI) has gaining prominence as a transformative technology capable of enhancing environmental monitoring, predictive modeling, and resource management through advanced data analytics and automation (Rolnick et al., 2019; Vinuesa et al., 2020). AI-driven systems are globally increasingly deployed across sectors such as energy, agriculture, urban planning, and climate governance, reshaping how environmental problems are understood and addressed. From the perspective of International Political Economy (IPE), however, technological innovations such as AI are embedded within global structures of power, capital, and governance. Control over AI technologies, data infrastructure, and intellectual property remains concentrated in developed economies and multinational corporations, raising concerns about unequal access and technological dependency (Strange, 1998; O'Brien & Williams, 2016). Consequently, the capacity of developing countries to leverage AI for environmental sustainability is shaped not only by technical readiness but also by global political economic relations that influence technology transfer, regulatory frameworks, and environmental governance. Nigeria offers a particularly important case for examining these dynamics. As Africa's largest economy and one of its most environmentally vulnerable countries, Nigeria faces persistent challenges including deforestation, air and water pollution, land degradation, and climate-related risks (Adelekan et al., 2021). Although national environmental policies and institutions exist, their effectiveness is often undermined by weak enforcement, limited funding, and institutional capacity constraints (Adeniyi et al., 2020).

At the same time, Nigeria has witnessed growing interest in digital technologies and AI-based solutions, especially in environmental monitoring, agriculture, and urban management, largely driven by private sector initiatives and international development partners.

The adoption of AI for environmental sustainability in Nigeria occurs within a broader global context characterized by uneven technological development and external influence. Many AI-driven environmental initiatives in Nigeria rely on foreign platforms, donor funding, and externally defined sustainability agendas, raising critical questions about data sovereignty, policy autonomy, and long-term sustainability (Zuboff, 2019; Crawford, 2021). From an IPE perspective, these conditions suggest that AI may reproduce existing patterns of dependency unless accompanied by deliberate efforts to strengthen domestic innovation systems and governance capacity. Despite the growing literature on AI and environmental sustainability, empirical studies that integrate these issues within an IPE framework remain limited, particularly in the Nigerian context. This study addresses this gap by empirically examining the implications of AI for environmental sustainability in Nigeria using a mixed-methods approach. By combining quantitative survey data, qualitative interviews, and secondary environmental indicators, the study seeks to explain how global political–economic structures, institutional capacity, and governance dynamics shape AI adoption and sustainability outcomes. The findings contribute to debates on technology, sustainability, and development and offer policy-relevant insights for leveraging AI in environmentally sustainable and politically equitable ways.

Statement of the Problem

Environmental sustainability challenges in Nigeria have intensified in recent decades, manifesting in deforestation, pollution, inefficient waste management, climate vulnerability, and unsustainable resource exploitation. Although Artificial Intelligence (AI) has emerged globally as a promising tool for improving environmental monitoring, decision-making, and resource efficiency, its application in Nigeria remains limited and uneven. Existing environmental governance structures are often constrained by weak institutional capacity, inadequate data systems, and poor enforcement mechanisms, which hinder the effective integration of AI into sustainability initiatives. As a result, environmental degradation persists despite the availability of advanced technological solutions.

Furthermore, the adoption of AI for environmental sustainability in Nigeria is deeply influenced by global political economic dynamics. Control over AI technologies, data infrastructure, and innovation systems is largely concentrated in developed economies, creating dependency relationships that limit Nigeria's technological autonomy. Many AI-driven environmental initiatives in Nigeria rely on foreign platforms, donor funding, and externally defined sustainability agendas, raising concerns about data sovereignty, policy alignment, and long-term effectiveness. Despite these challenges, empirical research that systematically examines AI and environmental sustainability in Nigeria within an International Political Economy framework remains scarce, creating a significant knowledge gap that this study seeks to address.

Aim and Objectives of the Study

The aim of this study is to empirically examine the role of Artificial Intelligence (AI) in advancing environmental sustainability in Nigeria within the framework of International Political Economy. The study seeks to understand how AI technologies are being deployed to address environmental challenges and to assess the extent to which these technologies contribute to improved environmental governance, monitoring, and sustainability outcomes. By situating AI adoption within broader political–economic structures, the study emphasizes that technological solutions are influenced by institutional capacity, governance systems, and global power relations.

To achieve this aim, the study pursues several specific objectives. First, it seeks to assess the contribution of AI applications to environmental sustainability practices in Nigeria, particularly in areas such as environmental monitoring, climate modeling, waste management, and resource efficiency. Second, the study aims to examine the institutional, infrastructural, and governance factors that shape the adoption and effectiveness of AI-driven environmental initiatives. Finally, it seeks to analyze how global political–economic forces including technological dependency, external financing, and international governance frameworks influence AI deployment and sustainability outcomes in Nigeria.

Research Questions

This study is guided by research questions that explore the interaction between Artificial Intelligence, environmental sustainability, and political–economic structures in Nigeria. The first set of questions focuses on the practical role of AI in addressing environmental challenges. Specifically, the study asks: To what extent is Artificial Intelligence currently applied in environmental sustainability initiatives in Nigeria, and how effective are these applications in improving environmental monitoring, decision-making, and resource management? The second set of research questions examines the structural and political–economic dimensions of AI adoption. The study asks: What institutional, infrastructural, and governance factors influence the adoption and effectiveness of AI-driven environmental sustainability initiatives in Nigeria? How do global political–economic forces such as dependence on foreign technologies, donor-driven projects, and international regulatory frameworks shape AI governance, data control, and sustainability outcomes in the Nigerian context?

1. LITERATURE REVIEW

1.1 Artificial Intelligence and Environmental Sustainability

Artificial Intelligence (AI) has emerged as a transformative tool in advancing environmental sustainability by enhancing data collection, predictive analysis, and decision-making processes. Scholars argue that AI applications such as machine learning, remote sensing, and automated monitoring systems have improved climate modeling accuracy, biodiversity conservation, waste management efficiency, and energy optimization (Rolnick et al., 2019; Vinuesa et al., 2020). Through real-time environmental surveillance and predictive analytics, AI enables governments and institutions to respond more effectively to environmental risks and resource inefficiencies. Despite these benefits, the literature also highlights significant sustainability concerns associated with AI deployment. High energy consumption, carbon emissions from data centers, and the environmental footprint of digital infrastructure raise questions about the net sustainability gains of AI technologies (Bender et al., 2021).

Moreover, the uneven global distribution of AI capabilities suggests that sustainability benefits are disproportionately realized in developed economies, while developing countries often remain technology consumers rather than innovators (Crawford, 2021). This dual nature of AI underscores the need to assess its environmental role within broader political–economic contexts.

1.2 International Political Economy and Technological Power

International Political Economy scholarship emphasizes that technological development is deeply embedded in global power relations, capital accumulation, and governance structures. Technologies such as AI are not neutral tools but instruments shaped by the interests of dominant states, multinational corporations, and global institutions (Strange, 1998; O'Brien & Williams, 2016).

Control over data, intellectual property rights, and technological standards often determines which actors benefit most from digital innovation. Within this framework, AI has become a strategic asset in the global political economy, reinforcing asymmetries between the Global North and Global South. Scholars argue that developing countries face structural barriers to meaningful participation in the AI economy due to limited access to capital, skills, and research infrastructure (Wallerstein, 2004; Zuboff, 2019). Consequently, AI-driven sustainability initiatives in developing economies are frequently shaped by external funding agencies and technology providers, raising concerns about dependency, sovereignty, and long-term development autonomy.

1.3 Environmental Sustainability and Governance in Nigeria

Environmental sustainability in Nigeria is closely linked to the quality of governance structures, policy frameworks, and institutional capacity at national and subnational levels. Nigeria faces persistent environmental challenges such as deforestation, pollution, land degradation, flooding, and climate change impacts, which are exacerbated by rapid urbanization and population growth. Effective environmental governance through laws, regulations, and enforcement mechanisms is therefore critical for managing natural resources sustainably and protecting public health (Olujobi, 2020).

While Nigeria has established environmental institutions and policies, gaps between policy formulation and implementation continue to undermine sustainability outcomes. Governance challenges affecting environmental sustainability in Nigeria include weak regulatory enforcement, limited coordination among institutions, inadequate funding, and political interference. Environmental regulations are often poorly enforced due to capacity constraints, corruption, and overlapping institutional mandates.

In addition, environmental decision-making tends to be centralized, with limited participation of local communities and civil society, reducing accountability and responsiveness to local environmental needs (O'Brien & Williams, 2016). These governance deficits limit the effectiveness of sustainability initiatives and contribute to the persistence of environmental degradation across different regions of the country. Strengthening environmental sustainability in Nigeria requires governance reforms that emphasize transparency, accountability, and inclusive participation. Integrating technological tools such as digital monitoring systems and data-driven decision-making can enhance regulatory oversight and improve environmental compliance. However, governance improvements must also address broader political–economic factors, including power relations, resource allocation, and policy coherence across sectors (Wallerstein, 2004; Crawford, 2021). By aligning environmental governance with sustainable development principles and strengthening institutional capacity, Nigeria can improve environmental outcomes and build long-term resilience against ecological and climate-related risks. Nigeria faces complex environmental sustainability challenges arising from rapid urbanization, extractive economic practices, weak regulatory enforcement, and climate vulnerability. Empirical studies document persistent issues such as deforestation, pollution, land degradation, and inadequate waste management systems (Adeniyi et al., 2020; Adelekan et al., 2021). Although environmental policies and institutions exist, implementation gaps remain a major obstacle to sustainable outcomes. The literature further notes that Nigeria's environmental governance challenges are closely linked to institutional capacity deficits and political–economic pressures. Resource dependence, particularly on oil and gas, has historically prioritized economic growth over environmental protection (Olujobi, 2020).

As a result, sustainability initiatives often lack adequate funding, technical expertise, and monitoring mechanisms. These governance weaknesses create both a challenge and an opportunity for AI-driven interventions, provided institutional reforms accompany technological adoption.

1.4 Artificial Intelligence Adoption and Sustainability

Artificial Intelligence (AI) adoption has become an important driver of sustainability efforts across environmental, economic, and social domains. In environmental management, AI applications such as machine learning algorithms, satellite-based remote sensing, and predictive analytics support real-time monitoring of ecosystems, early warning systems for climate-related risks, and optimization of energy and resource use. These technologies enhance the efficiency and effectiveness of sustainability interventions by reducing uncertainty and improving evidence-based decision-making (Crawford, 2021; Akanbi et al., 2022). As a result, AI adoption is increasingly viewed as a strategic tool for achieving national and global sustainability targets. However, the adoption of AI for sustainability is uneven across countries and sectors, largely due to institutional, economic, and technological constraints. In developing economies, limited digital infrastructure, shortage of skilled personnel, and high implementation costs restrict the scale and impact of AI-driven sustainability initiatives (Olujobi, 2020). Moreover, AI technologies are often imported, with ownership of data, algorithms, and platforms remaining in the hands of foreign firms. This creates dependency relationships that shape how sustainability solutions are designed and governed, reinforcing existing inequalities in technological access and decision-making power (O'Brien & Williams, 2016; Wallerstein, 2004). Sustainable AI adoption therefore requires governance frameworks that address both technical efficiency and political–economic implications. Integrating ethical standards, data protection measures, and local capacity development into AI strategies is essential for ensuring that sustainability outcomes are inclusive and context-specific (Crawford, 2021).

For countries like Nigeria, aligning AI adoption with national sustainability priorities, strengthening domestic innovation systems, and reducing reliance on externally controlled technologies are critical steps toward achieving long-term environmental sustainability.

Thus, AI adoption and sustainability are deeply interconnected processes shaped by governance choices and broader political–economic structures. Initiatives in Nigeria Studies on AI adoption in Nigeria indicate a growing but uneven integration of digital technologies across sectors such as agriculture, energy, urban planning, and environmental monitoring. AI-based tools have been used for flood prediction, climate data analysis, and smart waste management in pilot projects, often supported by international development partners (Akanbi et al., 2022). These initiatives demonstrate the technical feasibility of AI-driven environmental management in Nigeria. However, scholars caution that AI adoption in Nigeria remains constrained by inadequate infrastructure, limited skilled manpower, and heavy reliance on foreign technology platforms (Okafor & Adebayo, 2021). The lack of coherent national AI policies aligned with environmental sustainability goals further limits scalability. From an IPE perspective, these challenges reflect Nigeria's peripheral position in the global AI value chain, where technological dependency undermines the transformative potential of AI for sustainable development.

1.5 Linking Artificial Intelligence, Environmental Sustainability, and International Political Economy

Artificial Intelligence (AI), environmental sustainability, and International Political Economy (IPE) are increasingly intertwined in contemporary development and governance debates. AI technologies such as machine learning, big data analytics, and remote sensing have enhanced environmental monitoring, climate forecasting, pollution control, and resource management by improving the accuracy, speed, and scope of environmental decision-making (Akanbi et al., 2022; Crawford, 2021). These capabilities position AI as a critical tool for achieving environmental sustainability goals, particularly in contexts facing complex ecological challenges and limited conventional monitoring capacity.

From an International Political Economy perspective, however, the development, diffusion, and governance of AI are shaped by global power relations and unequal economic structures. Control over AI infrastructure, data, and intellectual property is largely concentrated in advanced economies and multinational technology firms, reinforcing technological dependence in developing countries (O'Brien & Williams, 2016; Wallerstein, 2004). As a result, AI-driven environmental sustainability initiatives are often externally financed and aligned with international development agendas, raising concerns about data sovereignty, policy autonomy, and the marginalization of local environmental priorities (Crawford, 2021). In the Nigerian context, the intersection of AI, environmental sustainability, and IPE reveals both significant opportunities and persistent structural constraints. AI offers promising solutions for addressing challenges such as climate change adaptation, waste management, and environmental degradation. However, limited domestic innovation capacity, weak institutional frameworks, infrastructural deficits, and reliance on foreign technologies constrain effective implementation (Akanbi et al., 2022; Olujobi, 2020). Addressing these challenges requires strengthening national technological capabilities, promoting inclusive AI governance, and situating sustainability policies within a political–economic framework that prioritizes equity, local relevance, and long-term environmental resilience. Emerging literature increasingly calls for integrating AI and environmental sustainability debates within an IPE framework. Such integration highlights how global governance regimes, market forces, and power asymmetries shape technology-driven sustainability outcomes (Bernstein, 2013). AI-based environmental solutions are often embedded in global policy agendas such as the Sustainable Development Goals, which may not fully align with local development priorities. Scholars argue that without addressing global inequalities in technology access and governance, AI may reproduce existing patterns of dependency rather than promote sustainable transformation (Frank, 1967; Vinuesa et al., 2020).

This study builds on this literature by empirically examining how these international political economic dynamics shape AI and environmental sustainability outcomes in Nigeria.

2. METHODOLOGY

This study adopted a mixed-methods research design to examine the relationship between Artificial Intelligence, environmental sustainability, and governance within the framework of International Political Economy in Nigeria. The mixed-methods approach was considered appropriate because it allows for the integration of quantitative and qualitative data, thereby providing a more comprehensive understanding of both measurable outcomes and underlying institutional and political–economic dynamics. The quantitative component focused on capturing patterns, trends, and stakeholder perceptions of AI adoption in environmental sustainability initiatives, while the qualitative component explored deeper insights into governance structures, power relations, and global influences shaping AI deployment in Nigeria. For the quantitative phase, a structured questionnaire was administered to stakeholders drawn from environmental regulatory agencies, technology firms, academic and research institutions, and civil society organizations across selected Nigerian states.

A stratified sampling technique was employed to ensure proportional representation of these key institutions involved in environmental governance and digital innovation. The questionnaire contained closed-ended items measured on a Likert scale, covering areas such as AI applications in environmental management, institutional capacity, governance effectiveness, and sustainability outcomes. A total of 250 questionnaires were distributed, of which 210 were returned and deemed valid for analysis, representing an 84 percent response rate. The qualitative component involved semi-structured interviews with purposively selected key informants, including senior officials in environmental agencies, AI practitioners, policy experts, and representatives of non-governmental organizations.

The interviews focused on issues such as donor influence, data sovereignty, regulatory challenges, and the political–economic implications of AI-driven environmental initiatives. In total, 25 in-depth interviews were conducted, allowing for triangulation with survey findings and providing contextual explanations for observed quantitative patterns. Quantitative data were analyzed using descriptive statistics, including frequencies, percentages, and mean scores, with results presented in tables to enhance clarity.

Qualitative data were analyzed thematically through systematic coding to identify recurring themes related to governance, sustainability, and international political–economic influences. Ethical considerations were observed throughout the study, including informed consent, confidentiality, and voluntary participation. The integration of quantitative and qualitative findings strengthened the validity and reliability of the study and enabled a robust interpretation of the complex interactions between AI, environmental sustainability, and governance in Nigeria.

3. FINDINGS AND DISCUSSION

3.1 Socio-Institutional Profile of Respondents

Table 1. Institutional Distribution of Respondents (n = 210)

Institutional Category	Frequency	Percentage (%)
Environmental regulatory agencies	68	32.4
Technology/ICT firms	56	26.7
Academic and research institutions	44	1.0
Civil society organizations/NGOs	42	19.9
Total	210	100.0

The response rate of 84% is considered high for social science and policy-oriented surveys, suggesting strong interest and relevance of the research topic among targeted stakeholders. This level of participation enhances the credibility of the findings and reduces the likelihood of non-response bias, particularly in studies involving institutions with varying levels of capacity and engagement.

The institutional composition of respondents demonstrates balanced representation across sectors central to AI-driven environmental sustainability in Nigeria. Environmental regulatory agencies constitute the largest proportion of respondents, reflecting their statutory role in environmental monitoring, policy implementation, and enforcement. Their inclusion provides critical insights into governance capacity, regulatory constraints, and the practical challenges of integrating AI into environmental management systems. The substantial participation of technology firms and academic institutions underscores the growing role of digital innovation and knowledge production in addressing environmental challenges.

Technology firms contribute practical perspectives on AI deployment, infrastructure, and innovation barriers, while academics provide analytical and research-based insights. Civil society organizations further enrich the dataset by offering viewpoints on accountability, public engagement, and sustainability outcomes. From an International Political Economy perspective, this diverse institutional representation captures the interaction between state actors, market forces, knowledge institutions, and civil society, thereby strengthening the empirical foundation of the study.

3.2 Contribution of Artificial Intelligence to Environmental Sustainability in Nigeria

Respondents were asked to assess the effectiveness of AI applications in key environmental sustainability domains. The results (Table 2) indicate strong perceived benefits, particularly in environmental monitoring and data management.

Table 2. Perceived Effectiveness of AI in Environmental Sustainability (n= 210)

AI Application Area	Very Effective (%)	Effective (%)	Not Effective (%)	Mean Score
Environmental monitoring & surveillance	38.1	34.3	27.6	3.82
Climate modeling& Prediction	31.4	36.2	32.4	3.65
Waste management optimization	29.0	33.8	37.2	3.54
Energy efficiency& resource use	35.7	30.5	33.8	3.69

The mean scores suggest that AI is perceived as moderately to highly effective across environmental sectors. These findings align with studies showing that AI enhances predictive accuracy and real-time environmental decision-making (Rolnick et al., 2019; Vinuesa et al., 2020).

However, effectiveness remains uneven, reflecting limited scale and institutional integration in Nigeria. From an IPE perspective, this uneven impact illustrates how technological benefits are mediated by governance capacity and access to capital rather than by innovation alone (Strange, 1998).

3.3 Institutional and Infrastructural Constraints to AI Deployment

To assess constraints, respondents identified key barriers limiting the effective use of AI for environmental sustainability (Table 3).

Table 3. Major Constraints to AI Adoption for Environmental Sustainability

Constraint	Respondents (%)
Inadequate digital infrastructure	64.3
Limited technical expertise	59.0
Weak regulatory and policy frameworks	55.7
High cost of AI technologies	61.4
Dependence on foreign AI platforms	57.1

The findings show that infrastructural and institutional deficits are the most significant barriers. Over 64% of respondents identified inadequate digital infrastructure as a major constraint, reflecting Nigeria's broader development challenges. These results support earlier studies that link weak institutions and regulatory gaps to poor environmental governance outcomes in developing economies (Adeniyi et al., 2020; Adelekan et al., 2021). In IPE terms, these constraints are not merely domestic failures but symptoms of Nigeria's subordinate position in the global digital economy, where access to advanced AI systems is controlled by multinational corporations based in the Global North (Zuboff, 2019).

3.4 Relationship Between Institutional Capacity and AI Effectiveness

Correlation analysis was conducted to examine the relationship between institutional capacity and the effectiveness of AI in environmental sustainability (Table 4).

Table 4. Correlation Between Institutional Capacity and AI Effectiveness

Variables	**Correlation Coefficient (r)**	**Significance (p)**
Institutional capacity&AI effectiveness	0.62	0.01

The strong positive correlation ($r = 0.62$, $p < 0.01$) indicates that higher institutional capacity significantly improves AI effectiveness in environmental sustainability initiatives. This finding confirms that technology alone is insufficient without supportive governance structures, a position widely emphasized in political economy literature (O'Brien & Williams, 2016).

3.5 Global Political–Economic Influences on AI and Sustainability

Qualitative evidence from in-depth interviews indicates that global political–economic forces significantly shape the development and implementation of AI-based environmental sustainability initiatives in Nigeria. Respondents emphasized the dominant role of external actors in financing, designing, and governing AI-driven environmental projects, raising concerns about national autonomy, data control, and long-term sustainability.

Table 5. Global Political Economic Influences on AI-Based Environmental Initiatives in Nigeria

Identified Influence	**Frequency of Mentions**	**Percentage (%)**
Donor-funded or externally driven projects	20	80.0
Limited national control over environmental data	18	72.0
Foreign ownership of AI platforms and algorithms	17	68.0
Alignment with international agendas over local priorities	19	76.0
Weak domestic innovation capacity	16	64.0

The findings presented in Table 5 demonstrate that a significant majority of AI-based environmental sustainability initiatives in Nigeria are externally driven, with 80% of interviewees indicating that such projects rely heavily on donor funding or foreign technology providers.

This external dependence influences project design, implementation priorities, and sustainability objectives, often aligning them more closely with international development agendas than with locally defined environmental needs. As a result, national ownership and long-term continuity of AI-driven environmental initiatives remain limited. Concerns over data sovereignty and intellectual property control further underscore Nigeria's dependent position in the global AI ecosystem. Over 70% of respondents highlighted limited national control over environmental data generated through AI systems, while 68% pointed to foreign ownership of algorithms and platforms.

These patterns reflect broader International Political Economy dynamics in which technological power, data ownership, and innovation capacity are concentrated in the Global North. Such arrangements restrict Nigeria's ability to independently shape AI governance frameworks and limit opportunities for domestic technological learning and innovation. These findings strongly reinforce dependency theory, which argues that technological diffusion often reproduces global inequalities by positioning developing countries as technology consumers rather than producers (Frank, 1967; Wallerstein, 2004).

In the context of AI and environmental sustainability, Nigeria's reliance on externally controlled technologies constrains policy autonomy and decision-making power. Consequently, AI governance in Nigeria is shaped less by domestic environmental priorities and more by international political–economic forces that determine access to capital, technology, and knowledge. Addressing these structural constraints is therefore essential for achieving more equitable and locally grounded AI-driven environmental sustainability outcomes. who controls data, technology, and decision-making processes.

3.6 Discussion of Findings

Discussion of Findings The findings of this study demonstrate that Artificial Intelligence (AI) holds substantial potential to enhance environmental sustainability in Nigeria, particularly in the areas of environmental monitoring, climate prediction, waste management, and resource efficiency. Survey and interview results indicate that AI improves data accuracy, timeliness, and decision-making capacity within environmental governance institutions. This supports existing literature that identifies AI as a critical enabler of sustainability transitions through improved environmental intelligence and predictive analytics (Rolnick et al., 2019; Vinuesa et al., 2020). However, the findings also reveal that these benefits remain largely localized, project-based, and insufficiently scaled to generate transformative environmental outcomes at the national level.

A key contribution of this study lies in demonstrating that institutional capacity is a decisive factor mediating the effectiveness of AI-driven environmental sustainability initiatives in Nigeria. The strong positive relationship between institutional capacity and AI effectiveness confirms that technology alone cannot deliver sustainability outcomes without robust governance frameworks, skilled personnel, and regulatory coherence. This aligns with political economy arguments that emphasize the role of institutions in shaping development trajectories and technological outcomes (O'Brien & Williams, 2016). In Nigeria, weak regulatory enforcement, fragmented policy coordination, and limited technical expertise constrain the integration of AI into long-term environmental planning, thereby limiting its sustainability impact. The findings further reveal that infrastructural deficits and high implementation costs significantly undermine AI adoption for environmental sustainability. Inadequate digital infrastructure, unreliable power supply, and limited access to high-quality environmental data restrict the operational efficiency of AI systems.

These challenges are consistent with broader development constraints identified in the Global South and reinforce arguments that technological diffusion is uneven and shaped by structural inequalities in the global political economy (Wallerstein, 2004). Consequently, Nigeria's capacity to deploy AI for sustainability is conditioned by material and structural limitations rather than by technological availability alone. From an International Political Economy perspective, the study's qualitative findings highlight the influence of global power relations on AI-driven environmental sustainability in Nigeria. The reliance on foreign AI platforms, donor-funded projects, and externally defined sustainability priorities reflects Nigeria's dependent integration into the global digital economy. Control over data, algorithms, and intellectual property by multinational corporations raises concerns about data sovereignty and policy autonomy, supporting critical IPE arguments that technology can reproduce dependency rather than promote development (Frank, 1967; Zuboff, 2019).

In this context, AI becomes a site of political and economic contestation rather than a neutral sustainability solution. The findings also suggest that AI-driven environmental sustainability initiatives in Nigeria are often shaped by international environmental and development agendas, which may not fully align with local ecological realities or policy priorities. While alignment with global frameworks such as the Sustainable Development Goals can attract funding and technical support, it may also limit Nigeria's ability to design context-specific sustainability strategies. This tension reflects broader debates within global environmental governance regarding the balance between international coordination and national policy autonomy (Bernstein, 2013). Overall, this study advances the argument that AI-driven environmental sustainability in Nigeria must be understood as a political economic process embedded in global and domestic power structures.

The findings underscore that without deliberate efforts to strengthen institutional capacity, reduce technological dependency, and enhance domestic innovation systems, AI risks reinforcing existing inequalities rather than delivering inclusive and sustainable environmental outcomes. By empirically linking AI, environmental sustainability, and IPE, the study contributes to a more nuanced understanding of how digital technologies shape sustainability pathways in developing economies. These findings contribute empirically to IPE scholarship by illustrating how digital technologies intersect with environmental governance and development inequalities in a Global South context.

CONCLUSION AND RECOMMENDATION

Conclusion

This study examined the implications of Artificial Intelligence (AI) for environmental sustainability in Nigeria within the framework of International Political Economy, using a mixed-methods research approach. The findings show that AI has significant potential to enhance environmental monitoring, climate prediction, waste management, and resource efficiency in Nigeria. Empirical evidence from surveys and interviews indicates that AI-based tools improve data accuracy and support informed decision-making in environmental governance. However, these benefits remain uneven and largely limited to pilot initiatives, with minimal impact at the national scale. The study further reveals that institutional capacity, infrastructure, and governance structures play a decisive role in shaping AI-driven environmental sustainability outcomes. Weak regulatory enforcement, inadequate digital infrastructure, limited technical expertise, and high implementation costs constrain the effective deployment of AI technologies. Moreover, Nigeria's reliance on foreign AI platforms and externally funded initiatives reflects broader global political–economic inequalities that influence technology access, data control, and policy autonomy.

These findings confirm that AI adoption for environmental sustainability is not a purely technical process but one embedded in structural and political–economic realities. In conclusion, the study argues that AI-driven environmental sustainability in Nigeria must be understood as a political–economic process shaped by both domestic governance capacity and global power relations. Without deliberate efforts to strengthen institutions, develop local innovation systems, and engage strategically with global AI governance frameworks, AI risks reinforcing existing inequalities rather than delivering sustainable environmental outcomes. Integrating International Political Economy perspectives into technology and sustainability policies is therefore essential for achieving inclusive, effective, and long-term environmental sustainability in Nigeria.

Recommendations

To enhance the effectiveness of Artificial Intelligence in promoting environmental sustainability in Nigeria, there is a need to strengthen institutional and human capacity within environmental governance structures. Government agencies responsible for environmental regulation should invest in specialized training for staff, develop interdisciplinary expertise that combines environmental science and data analytics, and improve coordination among ministries and agencies. Strengthening regulatory frameworks to accommodate emerging digital technologies will also ensure that AI applications are effectively integrated into environmental planning, monitoring, and enforcement processes. In addition, significant investment in digital and environmental data infrastructure is essential for scaling AI-driven sustainability initiatives. Expanding broadband connectivity, improving access to reliable power supply, and developing national environmental data platforms will enhance the functionality and reliability of AI systems.

Public–private partnerships can play a critical role in mobilizing resources and technical expertise, while targeted support for local technology firms and research institutions will help build a sustainable domestic AI ecosystem tailored to Nigeria’s environmental challenges. Finally, Nigeria must strategically engage with global and regional governance frameworks to reduce technological dependency and protect national interests. This includes promoting fair technology transfer, safeguarding data sovereignty, and ensuring that international AI and environmental initiatives align with local sustainability priorities. Active participation in African and global AI policy dialogues will enable Nigeria to influence emerging norms and standards while fostering regional collaboration aimed at building collective capacity for environmentally sustainable and politically equitable AI development.

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CHAPTER 2
DIGITAL AGRIBUSINESS PLATFORMS AND WOMEN'S MARKET ACCESS IN DEVELOPING ECONOMIES

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INTRODUCTION

Background of the Study

Agriculture remains the backbone of most developing economies, employing a significant proportion of the rural population and contributing substantially to national GDPs. In Sub-Saharan Africa and South Asia in particular, smallholder agriculture dominates food production systems, with women constituting nearly half of the agricultural labor force. Despite their central role, women farmers continue to face systemic disadvantages in access to land, credit, extension services, and formal markets. The Food and Agriculture Organization (Cavatassi et al., 2025; Phillips et al., 2025) reports that gender gaps in agricultural productivity are largely driven by unequal access to productive resources rather than differences in capability. Closing these gender gaps could substantially increase agricultural output and improve food security outcomes. However, structural barriers embedded in institutional, cultural, and economic systems persist, limiting women's effective participation in higher-value markets.

In recent years, the rapid expansion of the digital economy has introduced transformative opportunities within agricultural value chains. Digital agribusiness platforms—defined as technology-enabled systems that facilitate production, aggregation, financing, marketing, and distribution of agricultural products—have become central to agricultural modernization strategies. These platforms include mobile-based e-commerce marketplaces, bundled service platforms integrating digital finance and logistics, AI-powered advisory systems, and blockchain-enabled traceability mechanisms. Empirical evidence suggests that such platforms reduce transaction costs, enhance price transparency, and facilitate direct producer–buyer linkages (Ma et al., 2024). By lowering search and negotiation costs, digital platforms can mitigate traditional market inefficiencies that disproportionately affect smallholder farmers. The relationship between digital agribusiness platforms and women's market access is increasingly gaining scholarly attention. While digital platforms theoretically reduce spatial and informational barriers allowing farmers to transact remotely and access broader markets women often experience lower adoption rates due to digital literacy gaps, limited smartphone ownership, and restricted access to internet connectivity (Paul Jr. et al., 2024).

In many rural contexts, women are less likely than men to own digital devices or control financial resources needed to invest in technology. As a result, the expansion of digital agriculture risks reinforcing pre-existing gender inequalities unless inclusion is intentionally designed into digital transformation policies. Recent studies provide evidence of both opportunities and constraints. Cha et al. (2025) demonstrate that the development of the digital economy significantly enhances farmers' livelihood resilience by strengthening access to digital finance and e-commerce markets. Similarly, Gao and Qiao (2025) find that social capital plays a critical role in facilitating multi-stage e-commerce participation, suggesting that cooperative membership and trust networks significantly influence platform engagement. However, these benefits are unevenly distributed. Women's weaker integration into formal market networks and lower levels of digital awareness reduce their participation in digital agribusiness ecosystems (Ogutu et al., 2025).

Bundled digital innovation models appear particularly promising in addressing multiple constraints simultaneously. Platforms that integrate input provision, advisory services, digital payments, credit scoring, logistics coordination, and output marketing create comprehensive ecosystems that lower entry barriers for smallholders (Ajambo et al., 2023). When designed inclusively, such platforms can reduce women's time burdens through remote transactions and mobile payments while enhancing income stability. Nonetheless, Lyu et al. (2025) caution that bridging the digital divide requires targeted interventions in skills development and infrastructure investment, particularly in marginalized rural communities.

Artificial intelligence (AI) and data-driven decision systems are further shaping digital agribusiness landscapes. Ozor et al. (2025) argue that responsible and gender-inclusive AI innovation is essential for preventing algorithmic bias in agricultural advisory systems, digital credit allocation, and market matching algorithms. Without gender-disaggregated datasets and inclusive design frameworks, AI-powered platforms may inadvertently exclude women farmers or misrepresent their production capacities. Thus, digital transformation in agriculture must be embedded within governance structures that prioritize equity and inclusivity.

Infrastructure and institutional readiness also play decisive roles in determining outcomes. Ma et al. (2024) emphasize that digital market linkage effectiveness depends on complementary investments in rural connectivity, transportation systems, and regulatory frameworks. Weak logistics networks and fragmented policies can undermine digital platform efficiency, limiting their potential to improve farm-gate prices. Moreover, legal and policy environments that restrict women's land ownership or financial autonomy further constrain their ability to leverage digital opportunities (Bedford, 2024).

The emerging literature therefore presents a nuanced picture. Digital agribusiness platforms offer significant potential to transform agricultural markets by reducing transaction costs, improving price discovery, and integrating value chains. However, women's ability to benefit from these platforms depends on intersecting factors including digital literacy, access to devices, financial inclusion, social capital, institutional support, and gender-responsive governance frameworks. While early empirical evidence suggests positive impacts on income and resilience, comprehensive gender-disaggregated analyses remain limited.

Given the accelerating investments in digital agriculture across developing economies, there is an urgent need to synthesize current knowledge on how digital agribusiness platforms influence women's market access. Understanding the enabling conditions and structural barriers is critical for ensuring that digital transformation contributes to inclusive economic growth rather than reinforcing systemic inequalities. This study therefore examines the theoretical foundations, empirical evidence, and policy implications surrounding digital agribusiness platforms and women's market participation in developing economies.

Problem Statement

Despite the rapid proliferation of digital agribusiness platforms across developing economies, significant uncertainty remains regarding their capacity to equitably enhance women's market access. While digital platforms are widely promoted as inclusive solutions capable of democratizing agricultural markets, empirical evidence indicates that structural gender inequalities persist in digital participation and benefit distribution.

Women farmers are systematically disadvantaged in terms of asset ownership, access to formal financial services, digital literacy, and control over productive resources (Phillips et al., 2025; Bedford, 2024). These constraints directly affect their ability to engage meaningfully with digital marketplaces, digital financial tools, and online value chain networks.

Although studies show that digital economy development improves market integration and livelihood resilience (Cha et al., 2025), gender-disaggregated analyses remain limited. Many digital agriculture interventions measure aggregate adoption and income effects without adequately distinguishing outcomes for women versus men. As a result, policy narratives often assume technological neutrality, overlooking how entrenched socio-cultural norms shape digital access and usage patterns. Paul Jr. et al. (2024) emphasize that unequal device ownership, digital skills gaps, and limited control over household income restrict women's participation in digital climate and market solutions. These disparities suggest that digital transformation may inadvertently reinforce existing inequalities if inclusion mechanisms are not deliberately embedded.

Furthermore, the architecture of digital agribusiness platforms themselves may introduce new forms of exclusion. Algorithmic credit scoring systems, AI-powered advisory tools, and data-driven market matching mechanisms often rely on historical datasets that may underrepresent women farmers (Ozor et al., 2025). In contexts where women have limited formal transaction histories, automated systems may classify them as high-risk borrowers or marginal producers, thereby restricting access to digital credit and premium markets. This raises concerns about algorithmic bias and the reproduction of gender inequality through technological infrastructures.

Infrastructure deficits compound these challenges. In many rural regions, unreliable internet connectivity, weak logistics systems, and limited electricity access constrain effective platform utilization (Ma et al., 2024). Women are disproportionately affected because they often operate in smaller-scale production systems with limited mobility and lower investment capacity. Even where platforms exist, the absence of complementary institutional support such as cooperative structures, extension training, and gender-responsive policy frameworks reduces their transformative potential.

Gao and Qiao (2025) demonstrate that social capital and cooperative membership significantly influence e-commerce participation, yet women frequently have weaker formal market networks. Moreover, while bundled digital innovation models integrating finance, logistics, and advisory services show promising results (Ajambo et al., 2023; Ogutu et al., 2025), adoption levels among women remain constrained by awareness and digital competency gaps. Lyu et al. (2025) highlight that bridging the digital divide requires targeted investments in skills training and inclusive infrastructure development. Without these supportive mechanisms, digital agribusiness platforms risk becoming instruments that primarily benefit already better-positioned male farmers or larger commercial actors.

Therefore, the core problem addressed in this study is the limited and uneven understanding of how digital agribusiness platforms influence women’s market access in developing economies. Specifically, there is insufficient integration of gender analysis within digital agriculture research, limited cross-context comparative synthesis, and inadequate theoretical linkage between transaction cost reduction and women’s economic empowerment outcomes. Addressing this gap is essential to ensuring that digital transformation contributes to inclusive and equitable agricultural development.

Justification of the Study

This study is justified on economic, social, policy, and academic grounds. Economically, women constitute a substantial proportion of the agricultural labor force in developing economies. Phillips et al. (2025) estimates that closing gender gaps in agrifood systems could significantly increase global GDP and improve food security outcomes. Enhancing women’s market access through digital platforms has the potential to increase household incomes, stimulate rural entrepreneurship, and strengthen value chain efficiency. However, without evidence-based strategies, digital investments may fail to generate inclusive growth. Socially, empowering women in agricultural markets contributes to broader development objectives, including poverty reduction, improved child nutrition, and enhanced community resilience. Empirical studies indicate that women’s income is more likely to be reinvested in household welfare and education (Bedford, 2024).

Therefore, ensuring that digital agribusiness platforms effectively integrate women is not merely a matter of technological efficiency but also of social equity and intergenerational development. From a policy perspective, governments and development partners are investing heavily in digital agriculture initiatives, often under national digital economy strategies and agricultural modernization frameworks. Cha et al. (2025) demonstrate that digital economy expansion strengthens livelihood resilience, but policy frameworks rarely include gender-responsive digital indicators. Understanding how platform design, regulatory frameworks, and infrastructure investments affect women's outcomes is crucial for aligning digital agriculture initiatives with Sustainable Development Goals (SDGs), particularly SDG 5 (Gender Equality) and SDG 9 (Industry, Innovation, and Infrastructure).

Academically, this study contributes to bridging fragmented research streams. Existing literature often treats digital agriculture, gender empowerment, and market access as separate analytical domains. Integrating transaction cost economics (Ma et al., 2024), digital inclusion theory (Paul Jr. et al., 2024), social capital frameworks (Gao & Qiao, 2025), and gender-responsive innovation systems (Ozor et al., 2025) provides a more comprehensive understanding of the mechanisms through which digital platforms influence women's economic participation. By synthesizing recent empirical evidence (2023–2025), this review advances theoretical and practical debates on inclusive digital transformation.

Finally, this study is justified by the urgency of preventing technological transformation from reproducing structural inequality. Digital agribusiness platforms are rapidly reshaping agricultural value chains. Decisions made today regarding platform governance, AI design, digital finance regulation, and rural connectivity investments will shape market structures for decades. A gender-blind approach risks institutionalizing disparities within digital infrastructures. Conversely, evidence-based, gender-responsive strategies can ensure that digital agribusiness becomes a vehicle for empowerment rather than exclusion.

Research Objectives

The present systematic research review aimed towards digital agribusiness platforms and women's market access in developing economies. The specific objectives are:

- To examine how digital agribusiness platforms influence women's market access.
- To analyze gender-specific barriers to digital platform adoption.
- To evaluate the effectiveness of bundled digital innovation models.
- To identify policy strategies for gender-inclusive digital agribusiness.

1. THEORETICAL FRAMEWORK AND CONCEPTUAL FRAMEWORK

Collective Theoretical Insights from Recent Literature (2023–2025)

Recent scholarship consistently indicates that digital agribusiness platforms influence women's market access through four interconnected mechanisms: reduction of transaction costs, enhancement of social capital, expansion of digital financial inclusion, and restructuring of institutional power relations within value chains. Across empirical studies conducted in Sub-Saharan Africa and Asia (e.g., Ma et al., 2024; Gao & Qiao, 2025; Cha et al., 2025; Ogutu et al., 2025; Lyu et al., 2025; Ozor et al., 2025; Paul Jr. et al., 2024; Ajambo et al., 2023), a recurring theme is that technology alone does not drive empowerment; rather, outcomes depend on complementary assets such as digital literacy, cooperative membership, infrastructure quality, and gender-responsive governance frameworks. Theoretical integration is therefore necessary to explain both enabling pathways and structural barriers.

Transaction cost economics (TCE): Transaction Cost Economics provides a foundational explanation for the role of digital agribusiness platforms in market access. According to TCE, market participation is constrained by search costs, information asymmetries, bargaining inefficiencies, contract enforcement challenges, and logistical coordination failures. In many developing economies, women farmers face disproportionately high transaction costs due to mobility restrictions, time poverty, and limited access to price information.

Ma et al. (2024) argue that digital platforms reduce search and negotiation costs by providing real-time price data and direct buyer linkages. Similarly, Gao and Qiao (2025) demonstrate that e-commerce participation reduces intermediary dependence, thereby increasing bargaining power. However, from a gender perspective, the theory must be extended: while platforms reduce structural transaction costs, women may face higher *access costs* (device ownership, digital skills acquisition, social permission to engage online). Thus, transaction cost reduction benefits are conditional upon overcoming entry barriers.

Social capital theory: Social capital theory emphasizes the role of networks, trust, and collective organization in facilitating economic participation. Digital platforms often rely on trust-based systems such as ratings, cooperative memberships, and peer learning networks. Gao and Qiao (2025) show that farmers with stronger social capital are more likely to engage in multi-stage e-commerce participation. For women, social capital may compensate for limited asset ownership by facilitating shared digital access and collective marketing.

However, women frequently possess weaker formal institutional networks due to exclusion from cooperatives or producer associations. Therefore, social capital acts both as an enabler and a gatekeeper. Digital agribusiness platforms that integrate group-based onboarding or cooperative-based digital literacy training may enhance women's inclusion more effectively than individualistic models.

Digital inclusion theory: Digital inclusion theory expands beyond mere access to technology and considers affordability, skills, autonomy, and meaningful usage. Paul Jr. et al. (2024) and Lyu et al. (2025) highlight that digital transformation in agriculture requires addressing the multidimensional digital divide—covering connectivity gaps, skills deficits, and socio-cultural constraints.

Women's digital exclusion is often rooted in structural inequalities such as lower educational attainment and limited financial control. From this theoretical perspective, digital agribusiness platforms influence market access only when embedded within inclusive ecosystems that address infrastructure, affordability, and digital literacy simultaneously.

Gender and empowerment theory: Gender empowerment frameworks emphasize access to resources, agency, and institutional change. Phillips et al. (2025) underscores that empowerment requires not only increased income but also enhanced decision-making power and control over productive assets. Digital platforms may improve women's income through better market prices, but empowerment outcomes depend on whether women control digital accounts, mobile payments, and financial transactions.

Ozor et al. (2025) further extend this discussion by introducing gender-responsive AI governance, arguing that algorithmic systems must incorporate gender-disaggregated data to prevent systemic bias in digital credit scoring and advisory services. Thus, empowerment theory highlights the need to examine power dynamics embedded within technological infrastructures.

Sustainable livelihoods framework (SLF): The Sustainable Livelihoods Framework provides a holistic lens linking digital platforms to livelihood resilience. Cha et al. (2025) demonstrate that digital economy development enhances resilience through financial inclusion and market diversification. Within SLF, digital agribusiness platforms can strengthen human capital (skills), financial capital (digital finance), social capital (network integration), and physical capital (logistics coordination). However, women's initial asset deficits may limit their ability to leverage these opportunities unless targeted interventions are implemented.

Conceptual Framework: The conceptual framework integrates the above theories to explain the relationship between digital agribusiness platforms and women's market access in developing economies.

Core independent variable: digital agribusiness platforms:

Digital agribusiness platforms encompass:

- E-commerce marketplaces
- Bundled digital innovation platforms (Ajambo et al., 2023)
- Digital financial services
- AI-enabled advisory and traceability systems

These platforms function as institutional intermediaries that restructure value chain interactions.

Mediating variables: The impact of digital platforms on women's market access is mediated through:

- Reduction in Transaction Costs (Ma et al., 2024)
- Improved Price Transparency and Market Information
- Digital Financial Inclusion (Cha et al., 2025)
- Enhanced Social Capital and Network Integration (Gao & Qiao, 2025)
- Digital Literacy and Skills Acquisition (Ogutu et al., 2025; Lyu et al., 2025)

Moderating variables:

The relationship is moderated by:

- Gender norms and socio-cultural restrictions
- Asset ownership disparities
- Infrastructure availability (connectivity, logistics)
- Policy and regulatory frameworks
- AI governance and algorithmic bias risks (Ozor et al., 2025)

Dependent variable: women's market access:

Women's market access is conceptualized as:

- Participation in formal and higher-value markets
- Improved farm-gate prices
- Stable buyer relationships
- Increased income control
- Enhanced bargaining power

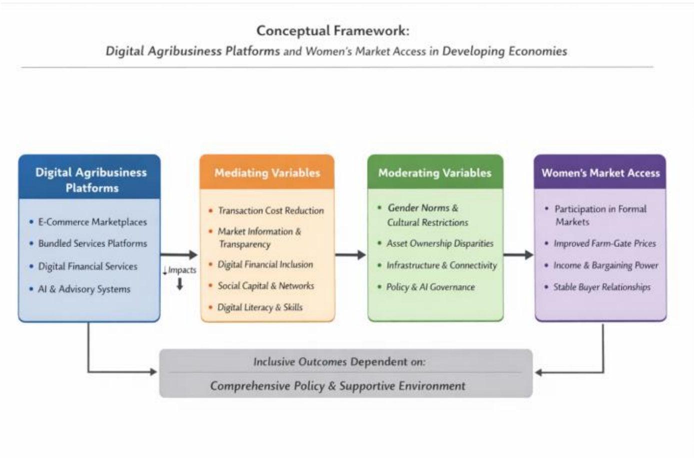

Figure 1. Conceptual Framework

Conceptual linkages (narrative representation): Digital agribusiness platforms reduce structural transaction costs and expand information access. When women possess adequate digital literacy and supportive social networks, these reductions translate into improved market participation. Digital financial services further enhance liquidity and investment capacity, strengthening competitiveness. However, where digital divides persist or gender norms restrict participation, the impact is attenuated. Policy interventions and inclusive governance frameworks therefore determine whether digital platforms produce empowerment or reproduce inequality.

2. RESEARCH METHODOLOGY

This study adopts a systematic literature review design to synthesize recent empirical and theoretical evidence on digital agribusiness platforms and women's market access in developing economies. Peer-reviewed journal articles, policy reports, and institutional publications published between 2023 and 2025 were identified through structured database searches using combinations of keywords such as "digital agriculture," "women farmers," "market access," "digital finance," and "developing economies." Inclusion criteria required gender-disaggregated analysis or explicit discussion of women's participation in digital platforms. Studies lacking methodological clarity or empirical grounding were excluded to ensure analytical rigor.

Data were analyzed using thematic synthesis. Extracted evidence was categorized into key domains: transaction cost reduction, digital inclusion, financial access, social capital, and institutional constraints. Comparative analysis across regions (Sub-Saharan Africa and South Asia) enabled identification of cross-context patterns, mediating variables, and policy-relevant insights.

3. RESULTS AND DISCUSSION

The synthesis of recent literature reveals that digital agribusiness platforms function as structural market intermediaries that reconfigure value chain governance, yet their gendered impacts are mediated by pre-existing inequalities in assets, capabilities, and institutional positioning.

Across developing economies, platforms demonstrably reduce transaction costs particularly search, negotiation, and enforcement costs thereby facilitating more efficient market participation (Ma et al., 2024). Women who access real-time price information and digital marketplaces are better positioned to negotiate fair prices and bypass exploitative intermediaries. However, transaction cost reduction alone does not automatically translate into equitable participation. Women often face higher initial access costs due to device affordability constraints, limited digital literacy, and socio-cultural restrictions on technology use (Phillips et al., 2025; Paul Jr. et al., 2024). This reveals a critical distinction between *market efficiency gains* and *equitable access to efficiency-enhancing tools*.

A second major analytical theme concerns digital financial integration. Platforms embedding mobile payments, digital credit, and insurance services strengthen liquidity and reduce cash-handling vulnerabilities. Cha et al. (2025) demonstrate that digital financial ecosystems enhance livelihood resilience by stabilizing income flows and facilitating productive investment. For women, digital wallets can increase autonomy over earnings, especially where cash-based systems are controlled by male household members. However, algorithm-driven credit scoring models often rely on historical transaction data, which may underrepresent women due to their previous exclusion from formal financial systems (Shkarupa et al., 2025; Ozor et al., 2025). Consequently, technological automation may unintentionally institutionalize gender bias unless corrective measures—such as gender-sensitive data inputs and alternative credit metrics—are adopted.

The analysis further highlights the centrality of social capital as both a catalyst and constraint. Digital platform adoption is rarely an individual decision; rather, it is embedded within collective networks and trust systems. Gao and Qiao (2025) show that cooperative membership significantly increases e-commerce participation, suggesting that network embeddedness lowers perceived risk and enhances information diffusion. Women's historically weaker representation in formal producer organizations reduces exposure to these network effects. Yet, when platforms are introduced through women's groups or community-based organizations, adoption rates improve substantially.

This indicates that social capital operates as a mediating asset capable of offsetting structural disadvantages. Bundled digital innovation models provide additional insight into systemic transformation. Platforms integrating input supply, logistics coordination, advisory services, and output marketing generate stronger outcomes than isolated digital tools (Ajambo et al., 2023; Khatri et al., 2024; Ogutu et al., 2025). For women, such integration reduces fragmentation in service access and mitigates time poverty by centralizing multiple functions within a single interface. However, Lyu et al. (2025) caution that infrastructural deficits—particularly limited broadband access and unreliable electricity—continue to constrain rural digital participation. These infrastructural gaps disproportionately affect women operating in remote or marginalized communities.

From a governance perspective, the literature underscores the importance of gender-responsive regulatory frameworks. The Bedford (2024) highlights those legal constraints on land ownership and business registration limit women's ability to leverage digital markets effectively. Digital agribusiness platforms cannot fully compensate for restrictive institutional environments. Instead, their impact is amplified when aligned with reforms that secure women's property rights, enhance financial inclusion policies, and promote inclusive digital literacy initiatives.

Overall, the deeper synthesis suggests that digital agribusiness platforms operate within complex socio-technical systems. Their transformative potential for women's market access depends on interaction effects among transaction cost reduction, financial inclusion, social capital, infrastructure readiness, and institutional reform. When these elements align, digital platforms enhance bargaining power, income stability, and value chain integration. When misaligned, platforms risk reinforcing stratification by privileging already advantaged actors. Thus, inclusive digital transformation requires systemic, multi-level interventions rather than technology deployment alone.

CONCLUSION, RECOMMENDATIONS AND POLICY IMPLICATIONS

Conclusion

Digital agribusiness platforms significantly enhance market access by reducing transaction costs, improving price transparency, and integrating logistics and finance. However, benefits for women depend on:

- Digital literacy
- Device ownership
- Access to finance
- Social capital
- Gender-responsive institutional frameworks

Without inclusive design, digital transformation risks deepening structural inequalities.

Recommendations

- Invest in women-centered digital literacy programs.
- Promote bundled platforms integrating finance, logistics, and advisory services.
- Strengthen women's cooperatives for collective digital engagement.
- Expand affordable smartphone and connectivity access.
- Institutionalize gender audits of digital agricultural platforms.

Policy Implications

- Integrate gender-responsive digital agriculture strategies in national agricultural policies.
- Support public-private partnerships targeting women agripreneurs.
- Develop regulatory frameworks ensuring fair platform governance.
- Align digital agriculture investments with SDG 5 (Gender Equality).

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CHAPTER 3
INTELLIGENCE PARADIGMS AND ARTIFICIAL INTELLIGENCE APPLICATION DOMAINS FOR INDIAN POLITICAL ECONOMY

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INTRODUCTION

With the continuous technological evolution of Silicon intelligence and Carbon intelligence in the past century and emulation of human intelligence attributes to artificial systems or gadgets by substituting human brain power to intelligent systems have been evolved. This resulted into evolution of artificial intelligence (AI). AI paradigm uses intelligent computing tools and gadgets that exhibit characteristics associated with intelligence in human behaviour. Various soft computing tools evolved include neural networks, fuzzy logic, genetic algorithm, expert systems, ant colony optimization, knowledge-based systems, neuro-fuzzy, simulated annealing, hybrid intelligent systems, particle swarm optimization, fish scooping, humanoid intelligent robots etc by emulating human intelligent organs like eye, ear, nose, tongue and skin and for actuation hands, legs. Sensors, actuators and computer memory for for brain. Human intelligence is termed as Carbon intelligence and AI is called as Silicon intelligence because Silicon chips are used. AI techniques used for advice, communication, control, decision making, goal seeking, learning, reasoning and pattern recognition etc. In artificial neural networks (ANN)simple artificial nodes called as neurons or neurodes or processing elements are connected together to form a network of nodes mimicking the biological neurons of human brain.

With the successful launching of Axiom-4 for human space programme reached ISS for staying 14 days on 26th June 2025 made the Engineers and Scientists to build more intelligent machines to travel long distances with self-guided vehicle and decision-making systems. From the second half of eighteenth century to present time six industrial revolutions (Industry 1.0 to Industry 6.0) have been evolved by creation of intelligent systems by replacing human muscular power and human brain power by intelligent robots and thinking machines. In the first Industrial revolution steam power, water wheels, spinning machines, mechanized industrial machines developed where muscular energy of human beings was substituted by machines and prime movers. With the advent of computers human brain power is given to the machines, neural networks, artificial intelligence (AI), machine learning (ML), intelligent robots, unmanned systems developed to Moon, Mars Venus, space etc.

Human beings have around 120 intelligent attributes which consists of activity attributes (cognition, memory, logical thinking, creative thinking and evaluation), material attributes (images, symbols, non-verbal perception and concepts) and product attributes (classes, relations, systems, unitary items, transformation and implications) and their combinations. Human brain operates on a parallel mode. Computer operates on serial mode. Neural network chips developed operate on parallel mode.

Artificial neural networks are data processing systems consusting of large number of simple, highly interconnected processing elements called artificial neurons in an architecture inspired by the structure of the cerebral cortex of the brain. Intelligence of machines is termed as Silicon intelligence whereas human intelligence is called as Carbon intelligence which is one of the major elements of human body composition of 60 elements. Human being is the weakest animal in the animal Kingdom but most intelligent because of brain power.

The various tools and techniques used for imparting intelligence to machines include Artificial Neural Networks, Genetic Algoriths, Fuzzy Logic, Expert Systems, Evolutionary Computing, Case Based Reasoning, Computer Vision and Image processing, CCD cameras, CID systems, Sensors, Actuators, Cybernatics, Probabilistic Reasoning, Approximate Reasoning, Soft and Hard Computing Analog VLSI Chips, Optical Devices, Analog Spatial Modulators, Optical Filters, Fourier Lens, Analog Neyral networks, and Holografic Systems. Use of high speed internet and intranet for transportation of data using Local Area Networks, Local Atrea Industrial Networks, Metropolitan Area Networks, Wide Area Networks, and Global Area Networks. The tools like World Wide Web, Multimedia, Intra and Extranets provide user friendly environments and global connectivity and communication.

The characteristics of intelligent machine and industrial systems are uncertainty or fault handling capability, optimality for goal achievement, learning capability, adaptivity, and user friendliness. Machine attributes for uncertainty include robustness, reliability, reactivity, complexity handling capability, fault diagnosis and tolerent, problem solving capability, and environment recognition with greater sensor resolution and range.

Optimality for goal achievement attributes include computational power, computation speed, number of processors, memory size, inter-process communication, Value judgement capability correctness, optimality, error rate, energy, time cost, planning capability, information processing ability. Learning and adaptivity attributes include supervised, unsupervised learning, reconfigurability, extensibility, adaptivity, generalization, local and global minima, and compatability. Human friendly systems are user interface capability, text, voice, keyboard, remote, command interpretation, autonomy, creativity and knowledge representation. The evolution of human intellect and machine intelligence is shown in Figure 1.

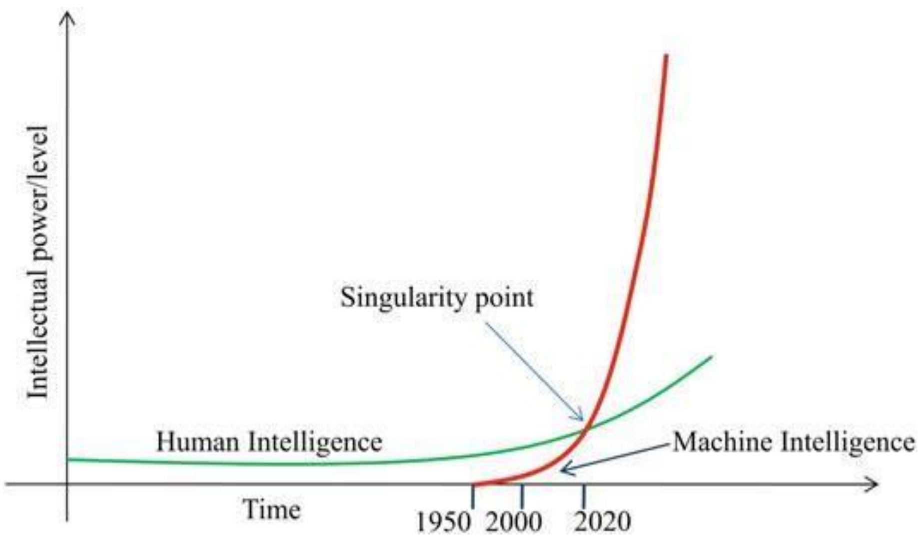

Figure 1. Evolution of Human and Artificial İntelligence

With the advent of computer, artificial intelligence, sensors, actuators, neural networks, the intellectual power of machines has been steeply increased. The point where the artificial intelligence outperforms the human intelligence is termed as singularity. In this century, machine intelligence is likely to supersede human intelligence. The human intellect has increased steadily and linearly through time, but artificial intelligence has been insignificant between 1950 and 2020 AD.

1. INTELLIGENCE AND ITS PARADIGMS

Intelligence is the ability to respond quickly and successfully to a new situation or the ability to learn from experience and to acquire intelligence. Human brain needs 10 watts of power to function. Human brain controls most activities of body, processing, integrating and coordinating the information it receives from sensory nervous system. Brain integrates the instructions sent to the rest of the body. Human body consists of Gross body (flesh, bones, hair etc.), Energy body (powers all the movements within us), Mental body (mental desires, fears, thought and emotions), wisdom body (our valuesand our higher intelligence) and Bliss body (deep joy and unconditional love). Brain also releases Gamma waves, Beta waves, Alpha waves, Theta waves, Delta waves, Epsilon and Lamda waves with different fequencies and uses 10 watts of power.

Human Intelligence and HIQ

Human intelligence is the mental ability to sustain successful life. It is the computational part of the ability to achieve the goals in the world. It is measured as Human Intelligence Quotient or simply Intelligence Quotient. It is an individual's ability to act purposefully, think rationally and deal effectively with environment.

HIQ = (Mental Age/Physical Age) x100

Emotional Intelligence and EIQ:

It is the ability to recognise, interpret and regulate your own emotions and understand those of other people. Its domains include self-awareness, self-management, social awareness and relationship management. EQ I test includes 133 questions and statements to participants, promting them to respond through a 5-point scale. It assesses 15 emotions into five separate factors. Average EQ in 100 scale is 75

One of the recent paradigms of intelligence is emotional intelligence. Although the concept of emotional intelligence was first used by the American psychologists Peter Salovey and John Mayer in 1990, it was Goleman who, thanks to his best-seller Emotional Intelligence (1995), made this construct famous.

Emotional intelligence includes both intrapersonal intelligence and interpersonal intelligence, and is composed of five elements: emotional self-awareness, emotional self-control, self-motivation, empathy and social skills. There are many investigations that affirm that emotional intelligence brings many benefits: it minimizes the effects of stress and prevents it, improves emotional well-being, improves interpersonal relationships, improves work performance.

Social Intelligence and SoIQ

It is a person's cultural fit and social awareness. Five elements of social intelligence are sympathy, self-awareness, empathy, meta-cognition and theory of mind. The original definition of social intelligence "the ability to understand and manage men and women and boys and girls, to act wisely in human relations. Social intelligence and interpersonal intelligence were previously believed to be closely related; however, the subjects diverged into two distinct fields of study. These multiple definitions demonstrate a lack of consensus on the operational definition of social intelligence. In psychology, Social Intelligence is a critical subset of human intelligence centered around two core components: social awareness and social facility. Social cognition refers to the capacity to understand and empathize with others' emotions and perspectives, while social facility pertains to the ability to behave effectively in social situations. The social intelligence quotient (SQ) is a statistical abstraction, similar to the 'standard score' approach used in IQ tests with a mean of 100. Scores of 140 or above are considered to be very high. Unlike the standard IQ test, it is not a fixed model. It can change their SoIQ by altering their attitudes and behaviour in response to their social environment. SoIQ had been measured by techniques such as question-and-answer sessions. These sessions assessed the person's pragmatic abilities to test eligibility in certain special education courses; however, some tests have been developed to measure social intelligence. Social Intelligence Quotient= (Social Age /Chronological Age) x100

Spiritual Intelligence and SpIQ

The word ‘spiritual’ derived from Latin word ‘spiritus’, which means that gives life or vitality to a system. Spiritual intelligence is a higher dimension of intelligence beyond the ego that has access to the mature qualities and advanced capabilities of the true self, in the form of wisdom, compassion, integrity, joy, love, creativity, and peace. Spiritual intelligence uncovers a deeper sense of meaning and purpose, and improves a wide range of important life skills and work skills. Many social scientists, psychologists, philosophers, thinkers, educators, educationists and educational concerns believe that intelligence is based on mind that is ability to develop mind and values mind. The five components of spiritual intelligence are ability to utilize spiritual resources to solve problems, ability to enter heightened states of consciousness, ability to invest everyday experiences, capacity for transcendence of physical and material, and capacity to be virtuous.

SpIQ = P(HIQ+EIQ)

Presence (P) is more than simply being aware of your immediate surroundings with greater clarity than usual. That’s only one of the results of presence.

Machine Intelligence and Machine Intelligence Quotient (MIQ)

The word for measuring machine intelligence is machine intelligence quotient (MIQ) which refers to the theory and advancement of computer systems that make it possible for them to accomplish jobs that ordinarily call for human intellect. Machine intelligence is the act of studying, classifying, and turning data into knowledge, where (machine) knowledge is referred to as the organized knowledge obtained and used to dispel ignorance and doubt on a certain job relevant to the intelligent machine. Control intelligence and interface intelligence are the two parts that make up machine intelligence. Interface intelligence describes the level of sophistication of human- computer interaction, including possible human-to-human and machine-to-machine communication. Machine control intelligence and machine interface intelligence may be combined to form the machine intelligence quotient.

A high machine intelligence quotient means that more choices are made by machines than by people, i.e., there are more interactions between machines and people than between machines and humans. In today's completely automated processes, robots make complicated judgments without any human input. The Machine Intelligence Quotient is a metric used for measuring the intelligence of automated systems introduced by Bien et al. Three measurements methods for the MIQ are discussed. These methods, however, are too broad and real-world control systems impossible to represent using them.

Artificial Intelligence (AI)

Few computers are already extremely faster and efficient than normal humans can ever be. For example, to crack a code of 2^{16} characters it would take humans to a few hours to finish but a high-speed computer with a good program can crack this in few minutes or less. Also, there are some computations which humans will not be able to finish in their whole lifetime whereas computers can finish these tasks in a few days. Thus, in a few ways computers are already way ahead of humans in terms of computation, speed and intelligence. However, this is limited only to specific tasks whereas humans even at an early age can be proficient at a number of tasks and machines are only being made intelligent by imitating humans. Artificial neural networks have been developed.

Linguistic Intelligence

It is the proficiency in using language effectively, both in writing and speaking. As the name suggests, is the ability to master the language. But this type of intelligence not only includes oral language, but also writing or gestures, so it has a lot to do with the communicative process. People who have high linguistic intelligence have a special sensitivity for the meaning of words, their order, sounds, rhythms, meter, etc. (For example, writers or poets).

Spatial Intelligence

Ability to visualize and manipulate spatial relationships and images.

Spatial intelligence is defined as the human ability to observe the world and objects from different perspectives and, in addition, it is the ability to manipulate or create mental images in order to solve problems. This type of intelligence is made up of different abilities: dynamic imagination, manipulation of images, artistic graphic skills or spatial reasoning, among others. People with high spatial intelligence are very good at puzzles or drawing. Sculptors, architects, painters or pilots are examples of individuals with high spatial ability.

Kinesthetic Intelligence

Capacity to use one's body effectively for expression or to solve problems. And the dancers, what kind of intelligence do they have? Well, according to the theory of multiple intelligences they have what is known as bodily or kinesthetic intelligence, which is the ability to use one's own body, that is, the coordination of body movements. This type and intelligence makes visible a great connection between the mind (and the emotions) and the movement, and, in addition to the dancers, it is usually possessed by actors or athletes.

Musical Intelligence

It is the skill in performance, composition, and appreciation of musical patterns. While some people are very good at sculpture or painting, others have an enormous capacity to elaborate musical pieces, because they recognize and compose tones and musical rhythms with great talent. These musically gifted people have high musical intelligence, allowing them to play instruments and read or compose musical pieces with ease.

Practical Intelligence

It is the ability to solve every day problems through the application of knowledge. These intelligences highlight the diverse ways in which individuals can excel and learn. There is no measurement technique available from the literature.

Interpersonal Intelligence

It is the ability to understand and interact effectively with others. You may have observed that there are certain individuals who have a unique ability to get along or relate to other people. They are individuals who use their interpersonal intelligence when interacting with others efficiently, as they are capable of understanding, empathizing and communicating appropriately. Interpersonal intelligence is the ability to discern the emotions and intentions of others and to interpret the words and gestures, or the goals and objectives of other people. Politicians, teachers or actors are advantageous in this type of intelligence.

Intrapersonal Intelligence

It is the capacity for self-awareness and self-reflection. There are individuals who possess a remarkable ability to understand themselves, their thoughts and emotions and regulate their own behavior, because they are able to access their feelings and emotions and reflect on them. Although intrapersonal intelligence encompasses self-knowledge and self-appreciation, it also includes understanding the human condition. Psychologists, philosophers or writers generally have a high capacity in this type of intelligence. In addition, these types of individuals tend to enjoy greater emotional and psychological well-being.

Naturalistic Intelligence

It is the ability to recognize and categorize plants, animals, and other aspects of the environment. Naturalistic intelligence refers to the sensitivity that some people show towards the natural world, as it is the ability to distinguish, order, classify, understand and use elements of the environment, objects, animals or plants. In the past, this type of intelligence was extremely important for survival. Biologists, farmers, botanists or hunters master this type of intelligence.

Existential Intelligence

Sensitivity to deep questions about human existence and the universe.

While some individuals go through the day without spending much time on the motive of things, people with high existential intelligence tend to meditate on their existence. These types of thoughts can include the meaning of life and death. Existential intelligence is known as the ninth multiple intelligences in Howard Gardner's theory, and he defines it is the ability to locate oneself with respect to the cosmos and with respect to the existential features of the human condition, such as the meaning of life and death, the final destination of the physical and psychological world in profound experiences such as love for another person. The search for meaning, self-knowledge, having one's own scale of moral values, aesthetic joy or the sense of mystery are some of the manifestations of this type of intelligence, which can be cultivated with the practice of meditation, contemplation or exercise. to philosophize and dialogue. While some authors speak of this type of intelligence as spiritual intelligence, others, on the other hand, affirm that they are two different types of intelligence, since existential intelligence goes far beyond spiritually positive and healthy behaviour, beyond being a good person.

Creative Intelligence

It is the capacity to generate new ideas and think outside the box. There are people who are made to work in a job that requires mechanical and monotonous work and who adapt without problems to work environments of this type. But instead, there are people whose minds seem to be flying, who are always one step ahead of others and who are constantly innovating. These people possess high creative intelligence. But what characterizes people with high creative intelligence? Fluency, that is, the ability to produce many ideas; the flexibility, to see and approach situations in different ways; and originality, to manufacture unusual or novel responses.

Collaborative Intelligence

Recently a new concept of intelligence has appeared in the organizational environment, it is collaborative intelligence. It could be defined as the ability to choose the best option to achieve a certain goal by working together, and is based on the idea of teamwork, so necessary for companies today.

In fact, teamwork is one of the skills that recruiters value the most, and that is why, faced with this new need when it comes to finding work, many masters or specialized courses in this type of intelligence are appearing.

National Intelligence and NIQ

It is the collective intelligence of all people of a nation. This varies from country to country. Japan has NIQ of 112.30 considering values, hardwork, respect teaches maths and science, promotes success. Hungary has NIQ of 111.23 based on legacy of maths and science, problem solving skills, science, technology, engg, Maths (STEM). Others countries Taiwan (111.19), Italy (110.83), South Korea (110.8), Serbia (110.6), Iran (110.27) and Finland (109.6). These eight countries have highest IQs in the world based on rich cultural history, teacher-student, technology, science based, long school hours and extra tutoring, effectiveness in education, significance for maths and science, learning more engaging and effectivess of learning.

Digital Intelligence

It is the ability to handle computer based digital systems and gadgets, software and hardware systems more efficiently.

Logical Mathematical Intelligence

It is the ability to conceptualize the logical relationships between actions or symbols (for example, a mathematician or scientist). In other words, it is the ability to reason deductively and logically and the ability to solve mathematical problems.

The psychologist Jean Piaget, when he studied, thought that he was working on a wide range of intelligences, but in reality, he was studying logical-mathematical intelligence. The speed to solve mathematical problems is the most common indicator to determine how much logical- mathematical intelligence an individual possesses. Intelligence is the broad mental capacity for logical reasoning, decision making, and learning. Intelligence includes cognitive processes such as perception, attention, memory, language, and planning due to its universal character.

Intelligence necessitates the potential to recognize the reality, make, and regulate action. The definition of "intelligence" is still unclear and is used to describe some useful smart property of each system. However, concept of intelligence seems to differ from person to person or one system to another. To accomplish the need of human-like control in automation, the notion of "intelligent control" was first proposed in the 1960s. Since then, various "intelligent" methodologies have been introduced to increase the flexibility and range of the mathematical model- based automatic control system. Intelligence is a collection of unique skills that have evolved in response to distinct circumstances. The traits of intelligence include adaptability to system, self-care, communication, autonomy, learning, self- refinement, inference, and creativity.

2. EMULATION OF HUMAN BODY AND ARTIFICIAL INTELLIGENCE

Intelligence Organs in Human Body

Human beings have eye for vision, ear for listening or hearing, tongue for taste and speaking, skin for touch and feel, brain for memory and decision making. Hands and legs are for motion and for performing tasks. These are emulated as sensors and actuators, and artificial neural networks. Human being has average brain weight of 1350 grams with around 10^{14} biological neurons and speed of 10^{16} interconnects per second. Human intelligence processing speed is around 400-500 Hertz. Machine intelligence has storage and speed of 10^{8} neurons and 10^{10} interconnects per second but processing speed (clock speed) of around 100-200 Mega Hertz. Computational energy or cost per computation of modern microprocessor chip is around 10^{-9} Joules per second for each operation using 1 watt power. Human brain has 10^{15} synopses and a nerve impulse of 10 times per second results into 10^{16} synopsis. Human brain uses 10 Watts poer 10^{-16} Joules of energy for each operation. Hence brain is more efficient by 10 million times computational effectiveness. Human brain has 10^{14} neuros, 10^{17} operations per second and 1350 grams. Human brain power has not changed much in thousands of years but computer 10^{18} floating point operations per second.

Human body of 70 kgs contains $7x10^{27}$ atoms with 60 chemical elements oxygen (65%), Carbon (18.5%), Hydrogen (9.5%), Nitrogen (3.2%), Calcium (1.5%), Phosphrus (1%) and others (less than 1%). Vital energy of 170 grams can be increased by physical activities like running, swimming, dancing, cycling etc, scientific dieting, physio therapy and sun bathing. Basically, four types of intelligence and their paradigms are Biological Intelligence, Artificial Intelligence, and Computational Intelligence.

Humanoid Intelligent Robot and AI Controls

Programmable logic controls, ANN, FL, GA, sensors, actuators, random access memory (RAM), content addressable memory, (CAM), bidirectional associative memory (BAM), temporal associative memory (TAM), and controls are neural, fuzzy, neuro-fuzzy etc. In learning paradigm include competitive, cooperative, reinforced, error-correcting, stochastic learning. Adaptability, self-care, communication, autonomy, learning, self-improvement, anticipating, goal-seeking, inference, and creativity are some characteristics of intelligence. Sensors are vision, tactile, environmental, motion, temperature, pressure audio sensors. Linear, rotary, pneumatic, hydraulic and smart actuators. In spite of huge software, middleware and hardware systems and algorithms developed all 125 human intelligence attributes are yet to explore for imparting to AI.

3. APPLICATION DOMAINS OF ARTIFICIAL INTELLIGENCE FOR INDIAN POLITICAL ECONOMY

Indian Political System: India is the largest populated country in the world with a population of 1.48 billion representing 17.72 percent of the total world population as of 2026 with a density of 451 people per square kilometer and median age of population is around 29.2 years, with males (51.6%) and Females (48.4%). It is the largest democratic country in the world. The total area of India is 3,287,760 sq. km. Major mother tongues include Hindi (26.6%), Bengali (7.94%), Marathi (6.84%), Telugu (6.84%), Tamil (5.69%), Gujarati (4.55), Urdu (4.19%), Bhojpuri (4.18%), Kannada (3.59%), Malayalam (2.87%) and others (26.9%). There are around 122 languages out of which 22 languages are specified in Eighth Schedule of Indian Constitution.

The number of seats in Lok Sabha- the lower house of parliament representing directly elected MPs has risen from 494 to 543 and has remained constant since then. In 1951 each MP represents 7,00, 000 people and today 2.5 million per MP. The Upper house i.e Rajya Sabha represents States' interests with seats allocated to 250. Rajya Sabha members are elected by State legislators.

India has a parliamentary system as defined by the constitution with power distributed between Union government and the States. The President of India is the ceremonial head of the state of the country and supreme commander- in- chief for all defense forces of India. The prime Minister of India is the leader of the party or political alliance of the legislative branch of the Government of India and head of the Union council of Ministers. India regionally divided into States (28) and Union territories (8). Each state is headed by a Governor and the legislative leader is the Chief Minister. Union territories (3 legislative and 5 non-legislative) are governed by Governor /an administrator/ Lieutenant Governor. All Governors and Lieutenant Governors are appointed by the President of India as per Constitution. Union of India and States have annual Budgets stating their revenue and expenditures. There should be large mechanism to collection of revenue and distribution of expenditure. Various technologies adopted for efficient way to reach various stakeholders.

4. ARTIFICIAL INTELLIGENCE APPLICATION DOMAINS

Digital India: India has the largest population in the world. To connect its people by manual systems is very difficult. Digital connectivity to all its citizens had been started more than a decade ago and most of the people are connected digitally by making netizens. AI plays an important role in digital connectivity through internet of things (IOT). Electronic voting and counting for Parliament and Assemblies, UTs: Indian elections are to br conducted every five years for large voters for parliament as well as States. In paper voting system large quantities of ballot papers are reuired and counting will also take significant time for declaring results. Electronic voting machines reduces time, cost and saving resources.

Digital Banking Systems and ATMs: Indian banking system has to handle billions of financial transactions for its customers every day. The service to the growing customers needs huge manpower to handle. Digital online transactions, automatic teller machines reduces cost, time and increases convenience to customers.

Census of Population and Electoral Updating: Census for more than 1.5 billion with required data in the formats will take years together and the analyses will also be difficult. Once in ten years population census is conducted. Electroral updating for the eligible new voters is also time consuming and costly. Digital systems and online updating and enrolment is considered very time and cost effective.

Data Analysis and Forecasting: Census analysis and forecasting of population growth, life expectancy, birth and death rates, literacy levels, rural and urban growth etc needs considerable technology utilization for effective administrative reforms ontime and for implementing corrective measures to be taken.

Social Security Systems and Public Distribution Systems: India has considerable population below poverty line. For these people Government has sevral schemes to poverty alleviation. Online distribution of financial, enrolement of people, monthly pension distribution, subsidy distribution, reaching them during CoViD pandemic period for nearly 800 million fron central government as state government is a challenging task. This problem is addressed by AI, ICT and digital systems effectively.

Aadhar Card Data Systems for Citizens:

All the citizens of 1.45 billion data are to be recorded and Aadhar identification cards are to be issued for various schemes, address proof etc. This gigantic work was processed and stored personal details for using various purposes. Without the use of AI and allied digital technology the task was highly difficult.

Weather Forecasting and Early Warning Systems: India is basically agricultural country. More than 70 percent people are living in villages and are dependent on agriculture. They periodically need weather data for their crops growth and necessary corrective steps to be taken as advised by agro-scientists.

Now-adays peasants are accessible to data by mobile phones for taking corrective steps for crops to prevent damage or loss of crops. Availability of manures supplies at subsidized cost by governments, financial support etc are available directly to the eligible farmers which reduces delay in reaching the subsidy of materials.

Natural Disastrous Prediction and Remedial Measures: Meteorology department forecasts weather in advance and inform the needy for necessary action to overcome adverse effects. India has large coastal areas and periodic cyclones, floods from rivers, avalanches from Himalayan snow hills etc saves life of fishermen, tourists.

Linguistic Translations/ Communication Systems: India has 15 major languages and more than 150 other languages. To communicate each other and one another from different linguistic groups in different states and in parliament, tourism places translation is required. This is done by computer or AI based systems effectively for better communication in India and abroad. These are faster, more accurate semantic analysis.

ICT and ML: Internet and Computer Technologies has changed the world significantly in manking the world a global village in 21st century. AI and Machine learning helps a lot in complex decision making easier.

Quantum Computing Systems and AI Combinations: AI does not replace human expertise and AI teams spend less time responding to incidents and more time to preventing them. Digital workspace provides new work styles across globe such as crowd sourcing, social networking, job sharing and microwork. Technology adoption is not just deploying latest innovations but designing systems that are scalable, resilient and trusted by those who use them. Quantum AI begins with recognizing how how principles of quantum mechanics can significantly enhance AI algoriths. Quantum computers use qubits (quantum bits) which has 0, 1, and 0 and 1 states whereas AI use binary bits 0 and 1. Qubits allow for simultaneous exploration of multiple possibilities, significantly enhancing computational speed and efficiency. These revolutionizing finance, health care, drug discovery, cyber security and creative industries. Quantum computers utilize qubits which can exist in multiple states simultaneously, enabling complex computations that were previously unattainable.

India AI impact summit 2026, New Delhi held during 16-20, February from 88 countries from global political leaders, CEOs, technologists addressed and discussed state of art, application domains, future of this technology fro global population. This industrial revolution is realized through industry 6.0 which is accomplished by implementing autonomous operations utilizing robots, AI, quantum computing, machine learning (ML), industrial internet of things (IIOT), block chain technologies, and cloud computing. Digital transformation from Industry 4.0 to industry 5.0 and subsequently Industry 6.0 worldwide or globally.

Health Care Systems and Drug Discovery: Providing health to all citizen as well as healthy society is one of the challenging responsibilities of pollical leaders. Prediction of future diseases from genetic code and blood profile, prevention diseases need large scale computations and drug discovery for new diseases. AI and Quantum intergration addresses this in less time and cost effective.

Environment and Climate Change: Global warming, earth quakes, sunamies, avelanches, carbon foot print by global leaders needs a strategic plan to reduce the pandemics. AI coupled with quantum systems address this faster.

Education and Networking Systems: India has the second largest educational system for largest 45% of youth population in the world. Education for all, skilling 220 million youth, reskilling in emerging areas, soft skills as National Policy on Education (NPE 2020) needs large networks to reach all the schools, colleges and universities with minimum or affordable financial resources. AI and quantum computing address this effectively.

CONCLUSION

Human being is most intelligent among all the species because of brain and learning ability from nature. Tacit knowledge gained over the past three Millenniums made human beings to gain supremacy over the Universe. In the present chapter intelligence and its attributes, paradigms of intelligence are highlighted. Emulation of human intelligent attributes and embedding them in AI are discussed. Application domains of AI for the largest country i.e India in the world are discussed in brief in addressing societal needs of people for political economy.

It is inevitable that every nation in the world in future need to use the emerging AI technologies at an accelerated pace for the benefit of the growing global population.

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