AI-DRIVEN

STRATEGIES FOR SUSTAINABLE DEVELOPMENT : BRIDGING MANAGEMENT, LAW AND SDGs

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Preface

The world stands at the crossroads of technological advancement and sustainable development, with artificial intelligence (AI) emerging as a pivotal force in shaping the future of global sustainability. AI's potential to accelerate progress toward the **United Nations Sustainable Development Goals (SDGs)** is undeniable, offering transformative solutions in governance, business, law, and environmental management. However, with such profound opportunities come equally complex challenges—ethical dilemmas, regulatory gaps, and the risk of technological disparities. This edited volume, ***AI-Driven Strategies for Sustainable Development: Bridging Management, Law, and SDGs***, brings together a diverse range of scholarly perspectives, offering an interdisciplinary exploration of how AI can be harnessed to address sustainability challenges while ensuring equitable, legal, and ethical governance frameworks. The book delves into AI's role in environmental conservation, corporate responsibility, legal regulations, and data-driven decision-making, providing a roadmap for scholars, policymakers, and industry leaders corresponding the intersection of technology and sustainability.

Each chapter, contributed by distinguished academics and experts, reflects a commitment to evidence-based research, critical analysis, and practical insights into AI's sustainable potential. The book not only highlights success stories but also critically evaluates AI's unintended consequences, advocating for a responsible and inclusive approach to AI governance.

We hope that this volume serves as a catalyst for deeper dialogue, interdisciplinary collaborations, and policy innovations that integrate AI-driven strategies with sustainable development imperatives. By fostering a nuanced understanding of AI’s role in law, management, and sustainability, this book aspires to contribute to a more equitable and technologically empowered future.

Prof. Deepshikha Datta,

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Acknowledgement

We extend our sincere gratitude to all those who contributed to the successful completion of this book, ***AI-Driven Strategies for Sustainable Development: Bridging Management, Law, and SDGs.*** First and foremost, we express our heartfelt appreciation to our very own Brainware University for their unwavering support and encouragement throughout this endeavor. Their guidance and resources have been instrumental in shaping the direction of this work. We are immensely grateful to our esteemed contributors, whose insightful research and scholarly expertise have enriched the content of this book. Their dedication and commitment to advancing knowledge in the fields of AI, sustainability, management, and law have been invaluable.

Special thanks to our reviewers and editorial team for their meticulous efforts in refining and enhancing the quality of this publication. Their constructive feedback and critical insights have greatly contributed to the academic rigor of this work. We also acknowledge the support of our families, friends, and colleagues, whose encouragement and patience have been a source of strength throughout this journey.

Lastly, we extend our gratitude to the publishers for their cooperation and professionalism in bringing this book to fruition. This book is a collective effort, and we hope it serves as a valuable resource in advancing sustainable development through AI-driven strategies.

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AI-Powered Surveillance vs. Privacy: Balancing Security and Civil Liberties in Criminal Jurisprudence

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ABSTRACT

The advent of Artificial Intelligence (AI) has revolutionized surveillance systems, offering unprecedented capabilities in crime prevention, detection, and investigation. From facial recognition technologies and predictive analytics to advanced video monitoring and real-time behaviour analysis, AI-powered surveillance has significantly enhanced the efficiency of law enforcement agencies. These technologies enable rapid identification of individuals, tracking of suspects, and monitoring of public spaces, making them invaluable tools in maintaining public safety and combating criminal activities. However, the growing reliance on AI-driven surveillance raises significant concerns regarding privacy rights, civil liberties, and ethical use. The widespread deployment of facial recognition systems and biometric data collection often occurs without adequate regulatory oversight, leading to risks of mass surveillance, wrongful identification, and potential misuse by authorities. Furthermore, the opacity of AI algorithms and the potential for bias in data sets can lead to discriminatory practices, disproportionately targeting marginalized communities and eroding public trust.

This paper explores the delicate balance between utilizing AI for enhanced surveillance in criminal jurisprudence and protecting individual privacy rights. It delves into the legal frameworks governing AI-powered surveillance across various jurisdictions, highlighting gaps in legislation and potential avenues for reform. The study also examines ethical dilemmas, such as the conflict between security needs and the right to anonymity, as well as the role of transparency and accountability in ensuring fair implementation. By analyzing real-world case studies and emerging technologies, this research aims to provide a comprehensive understanding of how AI-powered surveillance can be effectively integrated into criminal justice systems without compromising fundamental human rights. The paper concludes with recommendations for developing robust legal and ethical frameworks to mitigate risks while harnessing the transformative potential of AI in law enforcement.

Keywords: *AI Surveillance, Privacy Rights, Criminal Jurisprudence, Facial Recognition, Ethical AI*

INTRODUCTION:

Introducing Artificial Intelligence (AI) into a surveillance system is ushering in a new age of criminal jurisprudence, changing the way crimes are prevented, detected and investigated. Facial recognition, biometric analysis, predictive analytics and real time behaviour monitoring have given law enforcements around the globe more powerful tools to improve public safety and efficiency through the use of AI technologies. PwC report says AI could add up to $15.7 trillion to global GDP by 2030 as progress continues in public security and governance sectors. It also reflects the World Economic Forum, which finds that both AI in surveillance and in defence, have become critical drivers for transforming urban safety. (*Kumar & Patel, 2025*).

While the widespread deployment of AI in surveillance systems is accompanied by important concerns for privacy and civil liberties. However, these tools have the potential to be misused for mass surveillance, wrongful identification, and data exploitation, resulting in serious ethical and lawful concerns. As a part of a study by the National Institute of Standards and Technology (NIST), it was discovered that facial

recognition systems are extremely effective, but systematically biased by racial and gender factors. (*Reddy & Joshi, 2025*) These biases have resulted in wrongful identifications, and most impact on minority groups. For example, in the United States, AI driven facial recognition tools disproportionately flag African American people as suspects without first selectively profiling for race. It compounds systemic discrimination in policing already. Similarly, India, a rapidly digitizing nation, has come to swallow the AI powered surveillance tech too. The country has had some large-scale surveillance projects in the works — the National Automated Facial Recognition System (NAFRS), which aims to build a national database to help police. (*Singh & Gupta, 2025*) Further India's Aadhaar system is an expansive biometric database of the world's size, contributing to a crucial role in public governance and safety. But that has sparked a heated debate over the weak data protection law and the possibility of exploiting such sensitive personal data.

Around the world, China has led the way in AI surveillance adoption, using it as a means for real time facial recognition, and social credit systems. These systems have helped crime prevention but brought downfall of personal freedoms and they have been criticized by mass surveillance. On the other hand, the European Union has taken a wait and see approach by implementing the General Data Protection Regulation (GDPR) intended to protect individuals' privacy, and ensure the ethical use of data. But even within the EU there have been complaints about balancing rights against national security where exemptions have been granted (*WIRED, 2025*).

For example, AI powered CCTV networks for urban safety are seen in projects such as Safe cities in India. Facial recognition systems have been used in law enforcement in cities like Hyderabad and New Delhi for identifying suspects, and missing persons. According to reports, these systems have increased (*Sharma, 2024*) operational efficiency greatly, with authorities saying decreased response time and increased rates of crime resolution. But because of incidences of misuse, including the alleged monitoring of journalists and activists, greater safeguards are needed. On the one hand, a 2023 report by Freedom House reported India's internet freedom score as "partially free," blaming increased surveillance and restriction on privacy as some of the reasons.

At its heart is the tension between using AI for security at one end and the constitutional rights of privacy and personal liberty at another. In the Puttaswamy v. In the 2017 Union of India (2017) case, the right to privacy was assured as a fundamental right under Article 21 of the Constitution. It also took into account that the right needs to be counterbalanced by the interest of the state preventing anything that could jeopardize its national security.

In this paper, we investigate how the complex, interactive relationship between AI powered surveillance and privacy rights plays out in the context of India and globally. By examining technological legal frameworks, ethical considerations, and real-world case studies, this research aims to provide a comprehensive understanding of how AI can be effectively integrated into criminal jurisprudence without undermining fundamental human rights.

AI-POWERED SURVEILLANCE TECHNOLOGIES

- **Facial Recognition System**

  Facial recognition is a leading AI technology used by law enforcement across the globe to identify individuals based on their unique facial features. China uses over 600 million cameras under its Skynet Project for real-time monitoring (*Smith, 2020*)., and in the United States, more than 2,400 agencies are using the Clearview AI's systems. Some of the challenges include violation of privacy, bias in algorithms, and gaps in regulations. India's National Automated Facial Recognition System (NAFRS) aims to integrate facial recognition across the country, but there are concerns about transparency and data protection (*Gupta, 2021*).

- **Biometric Data Analysis**
  Biometric data analysis identifies individuals through physiological or behavioral traits, such as fingerprints, voice patterns, iris scans, and gait analysis. (*Patel, 2021*) This technology is widely used for access control, identity verification, and criminal investigations. India's Aadhaar Project is the world's largest biometric database, containing data on over 1.3 billion citizens, for purposes ranging from welfare distribution to law enforcement. The U.S. TSA utilizes biometric tools to enhance airport security, processing more than 2.5 million passengers per day. Data breaches: Sensitive biometric data can't be reissued like passwords; India's Aadhaar has been accused of having data leaks; unauthorized use: (*Mishra, 2021*) Biometric data can be used beyond the intended scope without rigorous oversight; ethical dilemmas: Collection usually occurs without the consent of people whose data is being collected, creating ethical dilemmas.
- **Behavioral Pattern Analysis**
  Behavioral pattern analysis makes use of AI algorithms to track and analyze the human behaviour in real-time for deviation that might lead to possible threats. These systems are based on analysis of body language, movement patterns, and other behavioral cues, such as excessive sweating or erratic movements that are identified by AI cameras at airports (*Wilson, 2020*). In Israel, AI-powered surveillance is applied to border crossings. In the European Union, it tested AI-powered behaviour detection in public spaces within the framework of the iBorderCtrl project aimed at increasing the safety of its borders. Behavioral pattern analysis is being explored as part of India's Safe City initiatives in metropolitan areas. These systems aim to enhance public safety, but critics argue that they lack the oversight needed to prevent misuse (*Chakraborty, 2021*).
- **Predictive analytics**
  Predictive analytics uses historical crime data and AI algorithms to predict future criminal activities and spot potential crime hotspots. It is a resource allocation tool for law enforcement. AI systems analyze patterns in crime data, such as time, location, and frequency, to predict where crimes are likely to occur. In the U.K., predictive analytics reduced property crimes by 15% in pilot areas like London and Manchester. In Los Angeles, PredPol has improved police deployment strategies, though it faces criticism for perpetuating biases. (*Kumar, 2020*) The cities of Hyderabad and Mumbai are exploring predictive policing initiatives, but these systems are controversial without any comprehensive studies on accuracy and ethical implications.

LEGAL FRAMEWORKS GOVERNING AI SURVEILLANCE

Constitutional Provisions: The Supreme Court of India in the landmark judgment, Justice K.S. Puttaswamy v. Union of India (2017), has declared the right to privacy a fundamental right under Article 21 of the Constitution. The judgments have clearly ruled that any infringement on privacy must satisfy tests of legality, necessity, and proportionality. However, the AI surveillance mechanism in India frequently operates in legal grey areas. (*Verma, 2021*) There is less transparency about these systems and their collection, storage, and processing of data.

Digital Personal Data Protection Act, 2023 (DPDP Act): This is the first dedicated legislation of India towards data protection which intends to govern personal data processing. Important provisions regarding consent-based collection and minimization of data are available; however, this act does have broad exemptions available for the government agencies. The DPDP Act under section 18 lets the government process personal data in the absence of explicit consent under "national security" and "public order" mandates. Critics are saying that it could lead to mass surveillance, destroying individual privacy. Information Technology Act, 2000 Although it was not specific for AI, it was relating to electronic transaction and digital governance with relevant sections dealing with data privacy and cyber security. (*Singh & Sharma, 2020*) It provides a legal structure for dealing with breaches and careless data practices indirectly affecting AI surveillance operations.

Information Technology (Intermediary Guidelines and Digital Media Ethics Code) Rules, 2021 These rules form guidelines for the digital intermediaries that impact the way AI system deals with users' data while ensuring accountability toward content management as well as other privacy practices. They play an important role in the governance of AI surveillance technologies of the digital space. (*Sharma & Joshi, 2021*)

Draft National Data Governance Framework Policy (NDGFP) Still under consideration, this policy aims to establish a comprehensive framework for data governance. It emphasizes ethical use and robust data protection mechanisms, though it awaits finalization and enactment.

National Strategy for Artificial Intelligence, 2018. This strategy paper is India's roadmap on how to approach the development of artificial intelligence in its country, thereby highlighting the relevance of ethics, addressing potential legal concerns, and the importance of responsible use of AI in surveillance- best practice global.

Principles for Responsible AI (2021) This set of guidelines focuses on ethical AI development and deployment, emphasizing fairness, transparency, and accountability. These principles guide the responsible use of AI surveillance technologies, which promotes public trust. **Rules on Deepfakes and Misinformation** These rules pertain to the production and dissemination of deepfakes and misinformation, (*Ding, 2020*) which are relevant to AI surveillance technologies. They ensure that AI is not used to manipulate information or infringe on individual rights.

PRIVACY ISSUES AND CIVIL RIGHTS

AI surveillance technologies have vast potential for increasing security and reducing crime, but their use also raises significant issues related to privacy and civil rights. Some of the key dimensions of these issues and their implications, especially in the Indian context, are presented below.

- **Mass Surveillance vs. Right to Privacy**

  The increasing use of AI surveillance systems blurs the line between security and privacy, leading to fears of creating a "surveillance state." AI technologies such as facial recognition systems, predictive analytics, and behavioral pattern analysis can collect and analyze vast amounts of personal data without individuals' consent (*Verma, 2020*).

  This directly challenges the fundamental right to privacy in India, as the Supreme Court had declared in Justice K.S. Puttaswamy v. Union of India (2017). The court ruled that the right to privacy is a fundamental right under Article 21 of the Constitution but also allowed reasonable restrictions when necessary for national security and public order. Nevertheless, mass data collection under AI surveillance frequently falls in legal gray areas that allow such mass collection and real-time monitoring to occur without enough safeguards, accountability, or mechanisms of oversight.

  For example, NAFRS and AI-based Safe City initiatives have been accused of indiscriminate data collection. The use of surveillance systems in public places—mostly implemented without any form of public participation—is against the principle of anonymity of persons since a citizen is subject to being monitored at all times. (*Kumar & Reddy, 2021*) In such a setting, the citizen may lose their right to freedom and privacy in favour of so-called security.

- **Abuse of Surveillance Data**

  One of the highest risks associated with AI surveillance technologies is the possible misuse of data collected. Sensitive personal data, such as facial images, biometric details, and location histories, tend to be centralised, and this creates vulnerabilities. Unauthorized access, data breaches, and exploitation of data for purposes beyond its intended scope are severe threats. The risks are well evidenced by India's experience with data breaches, most notably in regard to the Aadhaar database. For instance, in 2018, a report in the media revealed that Aadhaar data of millions had been made accessible online for a sum as meagre as ₹500. Vulnerabilities of a similar nature may exist within AI-driven surveillance databases,

especially where robust encryption and cybersecurity measures are absent. (*Singh, 2020*)

In addition, the Digital Personal Data Protection Act, 2023 (DPDP Act), while establishing a legal framework for personal data protection, grants broad government exemptions under Section 18. (*Rai & Sharma, 2023*) Agencies can process personal data without explicit consent for reasons of national security or public interest. Such provisions risk enabling unchecked state surveillance and undermine citizens' confidence in the security of their data.

- **Chilling Effect on Society**

The pervasive use of AI surveillance technologies may have the chilling effect on society, whereby persons change their patterns due to knowledge of being under constant scrutiny. This phenomenon affects the fundamental rights that guarantee freedom of speech, expression, and assembly under Articles 19(1)(a) and 19(1)(b) of the Indian Constitution (*Constitution of India, 1950*). Examples abound: Public protest and demonstrations-an essential part of a healthy democracy-may well decline as protesters and demonstrators fear possible retaliation or singled-out surveillance through AI-powered devices, such as predictive analytics or behavioral pattern analyses. Activists, journalists, and marginalized minorities will be impacted unfairly.

Real-life examples of such are realized in the following: using facial recognition technology to monitor protesters. For instance, in India, facial recognition systems have been reportedly used to monitor protests against CAA and so on. Such instances raise questions regarding where the state should draw the line between public order and citizens' peaceful right of dissent guaranteed by the constitution (*Iyer, 2020*).

ADVANTAGES OF AI SURVEILLANCE IN CRIMINAL JURISPRUDENCE

The AI-based predictive policing system analyses historical crime data to predict potential hotspots. The cities of Hyderabad and Mumbai, India are trying to implement predictive policing to combat the menace of crimes. Artificial intelligence can predict patterns in time, locations, and frequency, thus allowing law enforcing agencies to take preventive measures against crime and to bring down crime rates. AI algorithms can process huge volumes of data much faster, allowing for patterns and connections that would otherwise go unnoticed to human investigators. For example, the Delhi Police is set to use AI in crime patrols to speed up the investigation process, thus helping in solving cases quicker by scanning surveillance footages, social media activities, (*Verma & Jain, 2021*) and communication records. With accurate evidence analysis, AI can review forensic evidence such as DNA, fingerprints, and digital data with great precision. This means that the chances of human error are significantly reduced and results more reliable (*Singh & Mehta, 2020*). An AI system may cross-reference vast databases to find a match, which can sometimes be missed by human analysts, thus allowing for more accurate and conclusive evidence in the criminal trial. Facial Recognition AI facial recognition systems enable real-time matches of suspects with criminal databases that can help identify and apprehend offenders. The Indian government proposed to build the world's largest facial recognition system for policing in 2019. These facial recognition systems are installed in public places, airports, and highly secured areas where it tracks and identifies potential security threats.

The AI tools can be used to assess the risk of recidivism and help courts in making the decisions regarding bail, sentencing, and parole. Through the analysis of criminal history, behaviour patterns, and socio-economic conditions, AI provides useful insights into an individual's reoffending potential. This helps make the justice system more just and effective, ensuring that decisions are made based on data-driven risk assessments. AI systems can create detailed records of their analyses and decisions. These systems ensure law enforcement and judicial processes are more transparent and accountable. Detailed logs and reports from the AI systems improve public trust as well as encourage law enforcement agencies to work in a responsible manner (*Chandra, 2020*). Resource Optimization Through the automation of routine tasks and

analyses, AI enables law enforcement agencies to focus on the more complex and critical aspects of their work. This optimizes the use of limited resources as officers can now focus on activities that require human judgment and expertise. These can watch public places for suspicious behaviours to improve general public safety and security. Some systems can look out for irregularities in public, track activities, and provide an alert signal for the police and other enforcing bodies. As a case study, AI-powered cameras in airports are equipped to identify and note persons who have exhibited signs of stress or aberrant behaviour for better security situations (*Obhan & Associates, 2024*). These benefits allow AI to be transformative in criminal jurisprudence, allowing for an efficient, accurate, and fair justice system. However, it's worth addressing all the ethical issues to ensure robust oversight to prevent such misuse and safeguard individual rights.

RECOMMENDATIONS FOR BALANCING AI SURVEILLANCE AND PRIVACY

Transparency and Accountability: The AI surveillance systems should be transparent in their operations and decision-making processes. This includes clear documentation of how data is collected, analysed, and used. Regular audits and public reports can help build trust and accountability (*Patel, 2020*).

Robust legal frameworks: Provide wide-ranging legal structures that cover surveillance technologies by using AI. There should be effective protection of private rights but do not restrain lawful use of AI for security operations. Such a legal structure updated from time to time would better address new technologies and emerging problems (*Rai & Sharma, 2021*).

Consent and Data Minimization: Only collect data from individuals with their explicit consent. Only collect as much data as is necessary for the task. Data minimization practices help avoid privacy breaches and misuse of personal information.

Ethical Guidelines: Establish and comply with ethical principles for the use of AI surveillance technologies. These will include issues about bias, discrimination, and other forms of misuses. Ethics oversight committees could be used in enforcing these.

Public Awareness and Education: Inform the public on the benefits and risks of using AI surveillance systems. Public enlightenment programs can further enlighten them on their rights and the mechanism put in place to prevent privacy violations.

Privacy-Enhancing Technologies: Utilize privacy-enhancing technologies such as anonymization, encryption, and data masking to protect personal information. These technologies can help ensure that data is used responsibly and securely.

Regular Impact Assessments: Conduct regular impact assessments to evaluate the effects of AI surveillance on privacy and civil liberties. These assessments can help identify potential issues and inform policy decisions *(Patel & Sharma, 2021*).

International Cooperation: Collaboration with international partners to develop global standards and best practices in AI surveillance can help ensure consistency and fairness in the use of AI technologies across different jurisdictions (*Reddy & Kumar, 2021*).

♠ **Conclusion**

The emergence of AI-based surveillance technologies offers tremendous potential for transforming criminal jurisprudence, enhancing law enforcement capabilities, and improving public safety. However, this technological advancement also brings forth complex challenges that cannot be ignored—chief among them being the erosion of privacy, civil liberties, and the risk of state overreach. While AI surveillance tools promise to improve crime detection and prevention, their implementation, especially in countries like India, must be approached with caution to avoid compromising fundamental rights.

In the Indian context, where legal frameworks are still evolving, there is an urgent need for comprehensive legislation to regulate the use of AI in surveillance. The current legal landscape, including the Digital Personal Data Protection Act, 2023, offers some protection but leaves significant gaps, particularly concerning government exemptions for national security and public order. To prevent the misuse of

AI surveillance, it is imperative that India enacts laws that ensure transparency, accountability, and robust oversight mechanisms. Such regulations should address ethical use of AI, prevent misuse of data, and ensure surveillance systems are only deployed according to clear legal standards that align with constitutional rights. Furthermore, the algorithms of AI technologies, which in turn discriminate against marginalized communities, need to be handled with a lot of caution. AI systems should be regularly audited to ensure that they don't harbour any bias and act fairly, hence not increasing social inequalities through technology. Independent regulatory authorities should be provided with powers to govern the use of AI in surveillance and also the avenues for redressal against abuses. Public trust is also another critical element. Public consultation during the deployment of AI surveillance systems should be allowed, with open communication on data collection, storage, and utilization. Citizens have to be ensured that their privacy rights are not being affected and that there are safeguards available to protect the personal data in question. This will help instil confidence in these technologies and balance security and individual freedoms.

The future of AI-powered surveillance in criminal jurisprudence will continue to change with the passage of time. Policymakers will have to remain vigilant and responsive to emerging challenges, ensuring that India's approach to AI governance is flexible, adaptive, and forward-looking. By taking active steps to ensure the devising of strong regulations as well as ethics, India can further seize opportunities provided by AI in judicial procedures and avoid ideological substrates such as privacy, justice, and liberty that are basic to a democratic society. After all, this would ensure that AI remains a facilitator for good governance, adding to public security and protection of basic human rights.

-Smart AI - Powered mHealth Solutions: Accelerating Progress Towards Promoting United Nation's Sustainable Development Goal 3 (Good Health and Well-being)

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ABSTRACT

The global population is growing fast, which makes it more difficult for the underdeveloped countries to get good quality healthcare. In 2015, the United Nations, in response to narrow down the gaps, announced the Sustainable Development Goal 3 (SDG 3) to better the global public health. Healthcare is now being reformed by the use of mobile health (mHealth) apps that are powered by artificial intelligence (AI). They can be used in the monitoring of diseases, long-term illness management and tailored treatment delivery in real time.The Al together with Internet of Things (IoT) systems are used for gathering and examining health information to assist doctors in their decision-making processes, which results in the cutting down of medical mistakes.India has been spearheading the artificial intelligence health sector with initiatives like Ayushman Bharat and eSanjeevani, which together have increased healthcare accessibility. These results highlight the significance of the use of Al to save lives, cut costs, and improve health among communities that are otherwise underserved. Nevertheless, barriers such as data privacy, user trust, and equal access need to be resolved. Developers also need to first pay attention to strong security, sound app designs, and the use of the primary healthcare organization .Apart from the fact that it will be very effective, the mHealth applications using Al will have benefits that may range from cost- saving, global access, and improved outcomes in patient care. When humanity strive to be more innovative Al, it can assist us in reaching the Sustainable Development Goal (SDG) 3 and thus creating a better world in which people have a healthier existence and are also more equal.

1. INTRODUCTION

The world population growth is expected to continue, the average annual growth rate in 2015-2020 was about 1.1% (Gu et al., 2021). People from developing and underdeveloped countries do not have the access to cost effective and good quality treatments(Peters et al., 2008). To minimize the gap, Sustainable Development Goals 3 (SDG 3) were kicked off around 2015 by the United Nations as a concerted world effort to end poverty, caring for the environment, and bringing peace and prosperity to all the people by 2030, as spelt out in the United Nations 2030 agenda (Sorooshian, 2024).It is more important to concentrate on improving people's health because our population is growing very quickly.Real-time artificial intelligence based mobile health apps can perform many tasks like diagnose progress of health, build the link between problems and communication development, recognize the disease pattern, shield from the attacks of the disease, deal as well as keep an eye on chronic diseases, and offer the best suited treatment solution all the time (An et al., 2023).Affordable solutions are now being developed to identify and solve the difficulties of old healthcare systems, so that everyone gets equal opportunity to get good healthcare benifits.Mobile Health care applications can be easily integrate with Al methods to bring out countless benefits. For

example, automatic detection of disease which is chronic in nature is possible within few minutes, in addition to real-time prediction and suicide intervention foresight, aiding in emergency response, patient rehabilitation, caring for the patient without the need for invasive surgery, and the avoidance of medical errors (Bhatt et al., 2022) Communities are finding new ways to make medical care more reachable and powerful for good health everywhere.The futuristic approach of health applications will not only save time but provide accurate and user centric outputs which will speed up the decision making process(Cai et al., 2019).Smart technology helps people catch health problems early, making families stronger and healthier in new ways.Traditionally inputs has to provided by user in health applications which was not that much convinent, but now a days lots of healthcare organisations are collaborating with AI and IoT designers to make health applications more powerful to solve various health problems(Greco et al., 2020).New health ideas are helping countries build better medical support that matches what people really need worldwide. With the help of custom algorithm Inputs are now collected automatically from users, processes within the device itself and based on user preferences, outputs are displayed in a very interesting yet informative manner(Fleury & Chaniaud, 2023).

2. MAJOR GOALS

Some of the major goals are decreasing death rates of mothers due to pregnancy-related causes to improve sexual health (Amu et al., 2022), management of preventable baby deaths and children by the better accessibility of the medical facilities (Kruk et al., 2018),dealing with health threats such as malaria and tuberculosis by strengthening monitoring and treatment systems (Hogan et al., 2017), helping people live longer by endorsing healthy habits that prevent non- communicable disease (Bulc et al., 2017).

3. PRE AI AND POST AI GOAL ACCOMPLISHMENT

3.1 Pre AI era scenario

Throughout 2020, the global maternal health issue was very severe, with almost 800 preventable pregnancy-related deaths happening on a daily basis, mainly seen in the low and middle-income countries (World Health Organization: WHO, 2024). Children around the world received 86% of the diphtheria-tetanus-pertussis (DTP3) pandemic in 2019. (Muhoza et al., 2021).The incidence rate of tuberculosis dropped down by 13.5% between 2015 and 2020 (Falzon et al., 2023). In India, among 788 districts, only 9% have successfully achieved the Neonatal Mortality Rate (NMR) target under sdg 3 which is to be achieved within 2030 (Bora & Saikia, 2018). Many apps failed to be popular and get used by healthcare workers because they were not made just for them. Hardly anyone at one clinic used the tools properly, less than 1 in 5 (Thies, 2017).In pre-Al times, health apps couldn't gather enough data , and as Chronic illness caused most deaths, people required better solutions (Chen et al., 2021).

3.2 AI era scenario

Al-Enhanced Infectious Disease Surveillance detects diseases by looking at records such as travel, weather information, and social media to find patterns that show a potential outbreak, which allows early response to these diseases (Suvvari & Kandi, 2024).Al therapies have helped consumers by allowing mHealth apps to get personalized health recommendations which through personalized interventions increasing the adherence by up to 50% will gain the users trust and keep them engaged (Bakker, 2023). Al integration in mHealth apps supports data-driven decisions by analyzing health metrics and their links to socioeconomic factors, with some claims suggesting data- driven interventions could improve health outcomes by up to 40% (Cerf, 2019). Al technologies have expanded mHealth app accessibility, thus optimizing resource allocation and improving healthcare delivery in underserved areas (Adem, 2024).

4. BENIFITS OF USING AI ENABLED HEALTH CARE APPLICATIONS

Mobile apps can help mothers and children get medical care in low-income places. If the apps are used more babies and moms will get care. This means many mothers and babies might live longer lives (Kabongo et al., 2021). Health apps help people talk to doctors.This helps stop problems early. The doctor makes a special plan for each person. This helps lower long-term disease things and keeps people taking their meds, which gives better health results(Kaium et al., 2019). Using Al in healthcare can make it better. Al tools help doctors be more accurate. So, more patients trust them. When people know Al can make them healthier, they want to use it regularly(Esmaeilzadeh, 2020). Mobile apps are helping community healthcare workers reach people in rural areas. Special tools improve the care which they render to patients with the help of artificial intelligence. Many communities are served in new ways by the use of mobile health services(Viljoen et al., 2023). Digital health apps are great to help with problems like diabetes and obesity. They use artificial intelligence to give patients advice and tips about their health. They look at patient's information and then suggests what to do next. This approach is helpful for those who have long-term diseases (Jakob et al., 2022). Al health apps are designed to keep people using them long term. They remind users to take care of their health and make health activities fun by turning them into games. These features are very important for sticking to health plans for a long time (Wong et al., 2023). mHealth apps use Al to gather lots of health data. This helps doctors make better decisions and create new public health programs(Thomas, 2023). Al assists in making health apps that suit each user. This allows them to be happy and healthy because they get to use apps that help them reach their health goals(Slater, 2024). The use of Al-generated health apps can help lower costs for hospitals and clinics. By cutting costs, health facilities can serve more people, especially in areas with few resources(Milne-Ives et al., 2020). Al-driven mHealth applications enable the use of stress, anxiety, and depression management methods, thus generally, upholding mental health while the world faces global health challenges (Early et al., 2019).

5. INITIATIVE TAKEN FOR DEVELOPMENT OF AI TECHNOLOGY FOR MOBILE HEALTHCARE APPLICATIONS, SPECIAL EMPHASIS ON INDIA

The healthcare industry in india is expected to be worth USD 650 billion and Al's growth in the Indian Healthcare market is estimated to reach USD 1.6 Billion by 2025 with a CAGR of 40.6% and (Ghosh et al., n.d.). The Biotechnology Industry Research Assistance Council (BIRAC), a Public Sector Enterprise under the Department of Biotechnology, Government of India, has financially supported more than 1,500 Startups, Small and Medium Enterprises (SMEs), and other Enterprises with a funding grant of Rs. 2,128 crores (Welcome to DBT India, n.d.). The Ayushman Bharat Digital Mission, which includes Ayushman Bharat Health Account (ABHA) and Aarogya Setu applications, is working on Al-based mobile health has already created 56.67 crore digital health accounts, 34.89 crore records, and connected 2.84 lakh healthcare professionals (Factsheet Details:, n.d.). eSanjeevani, an Indian government teleconsultation application, has conducted over 276 million teleconsultations, with 300,000 daily, to promote digital health equity for all (Dastidar et al., 2024).In 2022 total USD 1.4 billion was invested in indian health technology startup community to adopt AI technologies in mHealth applications for effectively fight against coronavirus (Statista, 2024).IndiaAI, an Independent Business Division (IBD), and Microsoft will set up AI Catalysts, Center of excellence to train 100,000 AI innovators in smaller cities by 2026 to promote innovation and community community engagement (IndiaAI and Microsoft Join Hands to Harness Artificial Intelligence's Potential for Inclusive Development and Economic Transformation, n.d.-b). Andrew Ng's fund has made its first investment in india by supporting Jivi, a gurugram based healthcare AI startup, which promotes diagonosis, health reports and administrative tasks by using AI, highlighting the rapid growth of India's AI healthcare sector projected to reach $22 billion by 2027 (Kamath, 2024).Kilkari, a mobile health service providing important health messages to mothers, and CHAHAK, an AI system enhancing healthcare

solutions, both help achieve SDG 3 by improving mother-child health outcomes (Verma et al., 2024). $100,000 equity free fund has been invested by UNICEF venture fund to budding startup companies in developing countries, supporting purpose driven healthcare apps like CareNX from India, Bitz ITC from Kenya, Moner Bondhu from Bangladesh, and Docokids from Colombia, all of which use AI technology to improve healthcare services, health education, mental health support, and pediatric care while working towards achieving Sustainable Development Goal 3 targets (UNICEF, 2024).An important collaboration between the Department of Biotechnology (DBT) and Sweden's Vinnova will ensure long-term, affordable, scalable AI health solutions to promote SDG 3, focusing on AI, biodesign, digitalization, and circular economy (Department of Biotechnology, Government of India & Sweden's Innovation Agency, 2023). AI is helping to save energy, improve medical tests, track wildlife, and make education better, among many other things (Harnessing Artificial Intelligence for Sustainable Development Goals (SDGs), n.d.).In 2018, health tech industries were funded USD 2 billion for AI innovation in USA for development of precise disease detection, errorless medication system and quick and accurate decision support system(Mrazek et al., 2020).

6. CHALLENGES & RECOMMENDATIONS

Health apps on mobile devices are continuously facing significant challenges, one of which is the concern about data privacy, security, and unequal technology access. The issu can be addressed by implementing strong encryption methods and advanced data protection measures, ensuring that user information remains secure and these apps are made available to a wider public (Okolo et al., 2024). Access to technology disparities and unclear reporting of mHealth app features can lead to their ineffectiveness and health inequities worsening patient health, however, measures such as increasing digital literacy and better reporting quality can close the gap and improve user engagement (Iribarren et al., 2021). mHealth apps commonly have a problem with maintaining user engagement, which might get solved by implementing behavioral science techniques such as gamification and regular feedback in order to improve the interaction and motivation (Standen & Rothman, 2023). The use of Al in Health apps may make it easier for people to acquire health care, but it is important for developers to be explicit in explaining how their systems work and to avoid any ethical or legal problems (Zawati & Lang, 2024). One of the effects of mHealth apps is that they have caused healthcare providers a lot of anxiety, thus leading to a gap in care.Nevertheless, if there is better communication and collaboration between app developers and healthcare providers, then they can fix it and enhance the patient's health (Larson, 2018). Although the mobile health app market is seeing its global expansion, there is still not much evidence to show that these apps will change health behaviors effectively, thus causing a difficulty in getting the wider acceptance of them; hence, performing randomized controlled trials is a must for gathering the necessary evidence to promote such health behavior changes (Han & Lee, 2018). The reason why most mHealth apps do not succeed in engaging and keeping users is the poor design, and that is why the developers should ask the users to be a part of the design process to make the apps more user-friendly and effective (Bearne et al., 2020).

7. CONCLUSION

Healthcare is being transformed by Al- based mHealth apps enabling people to have a better and cheaper experience. Users can receive directly and transfer the data hence this assists them with staying healthy or those with chronic illnesses can manage their cases easier and less children and mothers will die. Initiatives including the Al-driven healthcare system Ayushman Bharat show how it is possible to provide affordable healthcare to all and assure that it is inclusive. In spite of this,such matters as data security and user involvement frequently go unnoticed. Al-powered mobile health applications with new engineering and elaborate protections can become the driving forces for better healthcare globally. These highly sophisticated technologies can support the implementation of the third SDG through enabling equal healthcare delivery and improving universal health outcomes.

♠ References:

1. Gu, D., Andreev, K., & Dupre, M. E. (2021). Major trends in population growth around the world. China CDC Weekly, 3(28), 604–613. https://doi.org/10.46234/ccdcw2021.160
2. Peters, D. H., Garg, A., Bloom, G., Walker, D. G., Brieger, W. R., & Rahman, M. H. (2008). Poverty and access to health care in developing countries. Annals of the New York Academy of Sciences, 1136(1), 161–171. https://doi.org/10.1196/annals.1425.011
3. Sorooshian, S. (2024). The sustainable development goals of the United Nations: A comparative midterm research review. Journal of Cleaner Production, 453, 142272. https://doi.org/10.1016/j.jclepro.2024.142272
4. An, Q., Kelley, M. M., Hanners, A., & Yen, P. (2023). Sustainable development for mobile health apps using the Human-Centered Design process. JMIR Formative Research, 7, e45694. https://doi.org/10.2196/45694
5. Bhatt, P., Liu, J., Gong, Y., Wang, J., & Guo, Y. (2022). Emerging Artificial Intelligence–Empowered MHealth: Scoping Review. JMIR Mhealth and Uhealth, 10(6), e35053. https://doi.org/10.2196/35053
6. Cai, Q., Wang, H., Li, Z., & Liu, X. (2019). A Survey on Multimodal Data-Driven Smart Healthcare Systems: Approaches and Applications. IEEE Access, 7, 133583-133599. https://doi.org/10.1109/ACCESS.2019.2941419.
7. Greco, L., Percannella, G., Ritrovato, P., Tortorella, F., & Vento, M. (2020). Trends in IoT based solutions for health care: Moving AI to the edge. Pattern Recognition Letters, 135, 346 - 353. https://doi.org/10.1016/j.patrec.2020.05.016.
8. Fleury, S., & Chaniaud, N. (2023). Multi-user centered design: acceptance, user experience, user research and user testing. Theoretical Issues in Ergonomics Science, 25(2), 209–224. https://doi.org/10.1080/1463922x.2023.2166623
9. Targets of Sustainable Development Goal 3. (n.d.-b). https://www.who.int/europe/about-us/our-work/sustainable-development-goals/targets-of-sustainable-development-goal-3
10. Amu, H., Aboagye, R. G., Dowou, R. K., Kongnyuy, E. J., Adoma, P. O., Memiah, P., Tarkang, E. E., & Bain, L. E. (2022). Towards achievement of Sustainable Development Goal 3: multilevel analyses of demographic and health survey data on health insurance coverage and maternal healthcare utilisation in sub-Saharan Africa. International Health, 15(2), 134–149. https://doi.org/10.1093/inthealth/ihac017
11. Kruk, M. E., Gage, A. D., Joseph, N. T., Danaei, G., García-Saisó, S., & Salomon, J. A. (2018). Mortality due to low-quality health systems in the universal health coverage era: a systematic analysis of amenable deaths in 137 countries. The Lancet, 392(10160), 2203–2212. https://doi.org/10.1016/s0140-6736(18)31668-4
12. Hogan, D. R., Stevens, G. A., Hosseinpoor, A. R., & Boerma, T. (2017). Monitoring universal health coverage within the Sustainable Development Goals: development and baseline data for an index of essential health services. The Lancet Global Health, 6(2), e152–e168. https://doi.org/10.1016/s2214-109x(17)30472-2
13. Bulc, B., Landers, C., & Driscoll, K. (2017). Data science: a powerful catalyst for Cross-Sector collaborations to transform the future of global health - developing a new interactive relational mapping tool. arXiv (Cornell University). https://doi.org/10.48550/arxiv.1710.11039

14. Kabongo, E., Mukumbang, F., Delobelle, P., & Nicol, E. (2021). Explaining the impact of mhealth on maternal and child health care in low- and middle-income countries: a realist synthesis. BMC Pregnancy and Childbirth, 21(1). https://doi.org/10.1186/s12884-021-03684-x
15. Kaium, M., Bao, Y., Alam, M., Hasan, N., & Hoque, M. (2019). Understanding the insight of factors affecting mhealth adoption. International Journal of Research in Business and Social Science (2147-4478), 8(6), 181-200. https://doi.org/10.20525/ijrbs.v8i6.522
16. Esmaeilzadeh, P. (2020). Use of ai-based tools for healthcare purposes: a survey study from consumers' perspectives. BMC Medical Informatics and Decision Making, 20(1). https://doi.org/10.1186/s12911-020-01191-1
17. Viljoen, A., Klinker, K., Wiesche, M., Uebernickel, F., & Krcmar, H. (2023). Design principles for mhealth application development in rural parts of developing countries: the case of noncommunicable diseases in kenya. Ieee Transactions on Engineering Management, 70(3), 894-911. https://doi.org/10.1109/tem.2021.3072601
18. Jakob, R., Harperink, S., Rudolf, A., Fleisch, E., Haug, S., Mair, J., … & Kowatsch, T. (2022). Factors influencing adherence to mhealth apps for prevention or management of noncommunicable diseases: systematic review. Journal of Medical Internet Research, 24(5), e35371. https://doi.org/10.2196/35371
19. Wong, A., Bayuo, J., Wong, F., Chow, K., Wong, S., & Lau, A. (2023). The synergistic effect of nurse proactive phone calls with an mhealth app program on sustaining app usage: 3-arm randomized controlled trial. Journal of Medical Internet Research, 25, e43678. https://doi.org/10.2196/43678
20. Thomas, V. (2023). The vinyasa tool for mhealth solutions: supporting human-centered design in nascent digital health ecosystems. Jmir Formative Research, 7, e45250. https://doi.org/10.2196/45250
21. Slater, C. (2024). Insights from user experience and evaluation of a mobile health nutrition intervention for children with autism: a qualitative study. Journal of Human Nutrition and Dietetics, 37(6), 1439-1453. https://doi.org/10.1111/jhn.13365
22. Milne-Ives, M., Cock, C., Lim, E., Shehadeh, M., Pennington, N., Mole, G., … & Meinert, E. (2020). The effectiveness of artificial intelligence conversational agents in health care: systematic review. Journal of Medical Internet Research, 22(10), e20346. https://doi.org/10.2196/20346
23. Early, J., González, C., Gordon-Dseagu, V., & Robles-Calderon, L. (2019). Use of mobile health (mhealth) technologies and interventions among community health workers globally: a scoping review. Health Promotion Practice, 20(6), 805-817. https://doi.org/10.1177/1524839919855391
24. World Health Organization: WHO. (2024, April 26). Maternal mortality. https://www.who.int/news-room/fact-sheets/detail/maternal-mortality
25. Muhoza, P., Danovaro-Holliday, M. C., Diallo, M. S., Murphy, P., Sodha, S. V., Requejo, J. H., & Wallace, A. S. (2021). Routine vaccination Coverage — Worldwide, 2020. MMWR Morbidity and Mortality Weekly Report, 70(43), 1495–1500. https://doi.org/10.15585/mmwr.mm7043a1
26. Falzon, D., Zignol, M., Bastard, M., Floyd, K., & Kasaeva, T. (2023). The impact of the COVID-19 pandemic on the global tuberculosis epidemic. Frontiers in Immunology, 14. https://doi.org/10.3389/fimmu.2023.1234785
27. Bora, J. K., & Saikia, N. (2018). Neonatal and under-five mortality rate in Indian districts with reference to Sustainable Development Goal 3: An analysis of the National Family Health Survey of India (NFHS), 2015–2016. PLoS ONE, 13(7), e0201125. https://doi.org/10.1371/journal.pone.0201125
28. Thies, K., Anderson, D., & Cramer, B. (2017). Lack of adoption of a mobile app to support patient self-

management of diabetes and hypertension in a federally qualified health center: interview analysis of staff and patients in a failed randomized trial. Jmir Human Factors, 4(4), e24. https://doi.org/10.2196/humanfactors.7709

29. Chen, M., Jeronen, E., & Wang, A. (2021). Toward environmental sustainability, health, and equity: how the psychological characteristics of college students are reflected in understanding sustainable development goals. International Journal of Environmental Research and Public Health, 18(15), 8217. https://doi.org/10.3390/ijerph18158217
30. Suvvari, T. K., & Kandi, V. (2024). Artificial Intelligence Enhanced Infectious disease surveillance - a call for global collaboration. New Microbes and New Infections, 62, 101494. https://doi.org/10.1016/j.nmni.2024.101494
31. Bakker, C. (2023). Nurses' roles in mhealth app development: scoping review. Jmir Nursing, 6, e46058. https://doi.org/10.2196/4605
32. Cerf, M. (2019). Sustainable development goal integration, interdependence, and implementation: the environment–economic–health nexus and universal health coverage. Global Challenges, 3(9). https://doi.org/10.1002/gch2.201900021
33. Adem, R. (2024). Linkages between the sustainable development goals and health in somalia. BMC Public Health, 24(1). https://doi.org/10.1186/s12889-024-18319-x
34. Ghosh, A., Bhattacharjee, B., nasscom, & Kantar. (n.d.). Advancing Healthcare in India: Navigating the Transformative impact of AI.
35. Welcome to DBT India. (n.d.). https://dbtindia.gov.in/dbt-press/government-offer-special-incentives-support-75-start-ups-areas-telemedicine-artificial
36. Factsheet details: (n.d.). https://pib.gov.in/FactsheetDetails aspx?Id=149066®=3&lang=1
37. Dastidar, B. G., Jani, A. R., Suri, S., & Nagaraja, V. H. (2024). Reimagining India's National Telemedicine Service to improve access to care. In The Lancet Regional Health - Southeast Asia (Vol. 30). Elsevier Ltd. https://doi.org/10.1016/j.lansea.2024.100480
38. Statista. (2024, August 30). Value of funding in healthtech startups across India 2014-2022. https://www.statista.com/statistics/1343869/india-value-of-funding-for-healthtech-startups
39. IndiaAI and Microsoft join hands to harness Artificial Intelligence's potential for inclusive development and economic transformation. (n.d.-b). https://pib.gov.in/PressReleasePage.aspx?PRID=2091170
40. Kamath, B. (2024, October 8). Andrew Ng's AI Fund invests in AI healthcare startup Jivi. YourStory. https://yourstory.com/2024/10/andrew-ngs-ai-fund-invests-in-ai-healthcare-startup-jivi
41. Verma, S., Lalan, A., Diaz, P. R., Danassis, P., Mahale, A., Sudan, K. M., Hegde, A., Tambe, M., & Taneja, A. (2024). Leveraging AI to improve health information access in the 42.World's largest maternal mobile health program. AI Magazine, 45(4), 526–536. https://doi.org/10.1002/aaai.12206
42. UNICEF. (2024). Four startups harnessing artificial intelligence to strengthen healthcare systems for children. UNICEF. https://www.unicef.org/innovation/stories/four-startups-harnessing-artificial-intelligence-strengthen-healthcare-systems-children
43. Department of Biotechnology, Government of India & Sweden's Innovation Agency. (2023). Cooperation within Health focusing on AI-based Digitalisation, Biodesign or Circular Economy: A Joint Call for Proposals under the Sweden-India Innovation Partnership. In DBT-VINNOVA JOINT CALL IN HEALTH [Report]. https://www.vinnova.se/en/calls-for-proposals/swedish-indian-cooperation/

44. Harnessing artificial intelligence for Sustainable Development Goals (SDGs). (n.d.). https://unsdg.un.org/latest/announcements/harnessing-artificial-intelligence-sustainable-development-goals-sdgs
45. Mrazek, M., O'Neill, F., IFC, & World Bank Group. (2020). Artificial intelligence and healthcare in emerging markets. In IFC [Report]. https://www.ifc.org/thoughtleadership
46. Okolo, N. C. A., Babawarun, N. O., Arowoogun, N. J. O., Adeniyi, N. a. O., & Chidi, N. R. (2024). The role of mobile health applications in improving patient engagement and health outcomes: A critical review. International Journal of Science and Research Archive, 11(1), 2566–2574. https://doi.org/10.30574/ijsra.2024.11.1.0334
47. Iribarren, S. J., Akande, T. O., Kamp, K. J., Barry, D., Kader, Y. G., & Suelzer, E. (2020b). Effectiveness of mobile apps to promote health and manage disease: systematic review and meta-analysis of randomized controlled trials. JMIR Mhealth and Uhealth, 9(1), e21563. https://doi.org/10.2196/21563
48. Standen, E. C., & Rothman, A. J. (2023). Capitalizing on the potential of mobile health applications as behavioral interventions: A research agenda for calorie-tracking and activity-tracking applications. Social and Personality Psychology Compass, 17(3). https://doi.org/10.1111/spc3.12731
49. Zawati, M. H., & Lang, M. (2024). Does an app a day keep the doctor away? AI symptom checker applications, entrenched bias, and professional responsibility. Journal of Medical Internet Research, 26, e50344. https://doi.org/10.2196/50344
50. Larson, R. S. (2018). A path to Better-Quality mHealth apps. JMIR Mhealth and Uhealth, 6(7), e10414. https://doi.org/10.2196/10414
51. Bearne, L. M., Sekhon, M., Grainger, R., La, A., Shamali, M., Amirova, A., Godfrey, E. L., & White, C. M. (2020). Smartphone apps targeting physical activity in people with rheumatoid arthritis: systematic quality appraisal and content analysis. JMIR Mhealth and Uhealth, 8(7), e18495. https://doi.org/10.2196/18495

Suicide in India : Challenges, Prevention Gaps , and the Harsh Reality

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ABSTRACT

Environmental factors are typically included in the complexities of the suicide phenomena. Even though many social, cultural, economic, and political correlates and risk factors have been identified, psychiatry continues to argue for curative solutions based on the reductionistic biomedical model rather than supporting public health measures to manage the larger sociocultural, economic, and political context. Although many individuals benefit from psychiatric and restorative treatment, the materialist theory, which attributes differences in health and lifespan to external factors, is the most compelling in explaining how the human body manages to keep going. Suicide prevention in the population as a whole is not an easy problem to solve, and targeted mental health treatments are not likely to reverse long-term suicide patterns.

Key Words: Prevalence; Mental health, Depression, Help-seeking, College students, Frequency

INTRODUCTION:

The prevalence of suicide has been identified as a serious issue for society. The World Health Organization recognises that suicide is a worldwide issue, especially in low- and middle-income nations. Those directly affected by suicide, as well as their loved ones, neighbours, and the larger community, all suffer as a result of this tragic act. The World Health Organization (WHO) acknowledges that many fatalities occur unexpectedly and call for efficient, all-encompassing, multi-sectoral responses and national policies for prevention.

It backs efforts to limit who can get their hands on things like pesticides, guns, and certain OTC drugs. Problems with mental health, such as alcohol and drug abuse, must be addressed. It lends credence to the argument for removing social stigma from mental health treatment and care. It promotes early intervention and makes suicide prevention a requirement. Suicide prevention is recognised as an important public health issue in the World Health Organization's Mental Health Gap Action Programme (mhGAP)2. It has compiled an intervention manual for dealing with those suffering from mental illness, drug abuse, suicide thoughts and planning, and a history of intentional self-harm. Suicide prevention is a top priority in the World Health Organization's Mental Health Action Plan 2013–2033. These include I a lower overall suicide rate, (ii) more effective suicide prevention programmes, and (iii) fewer suicide attempts that result in hospitalisation. The goal of the strategy is to reduce suicide rates by 10% by the year 2020. Furthermore, WHO has launched a multisite intervention research to raise public understanding, lessen associated stigma, and affect policy at the national level. The programme comprises a suicide mortality tracking system, technical assistance for nations, regional and national conferences, the creation and distribution of resources, advocacy, and randomised treatment trials of short therapies for suicide attempts.

Nonetheless, suicide is a topic that resurfaces sometimes in Indian culture, especially when data are released by the National Crime Records Bureau (NCRB). A yearly tradition in the nation is to talk about suicide, debate the causes, criticise the present ways, score political points, and spotlight certain alternatives. For reasons like the public's short attention span and the media's cyclical nature, stories about suicide are all too common.

DIFFICULTY IN MEASUREMENTS

The stated national suicide rate of 11 per 100 000 is widely acknowledged by academics to be an underestimate of the true scale of the issue. Problems are further complicated by the fact that attempted suicide is a criminal offence, with all the attendant legal ramifications, police investigations, post mortems in under-resourced settings, the lack of thorough coroner's findings, and social shame. The national sample confirms the higher rates seen in certain locations when reliable data gathering techniques were used. Police reports and NCRB statistics are the sole sources used to estimate suicide rates in the nation, although the researchers who created these numbers cast doubt on their accuracy and remove themselves from the data gathering process.

CORRELATES AND FOCUS

Partial perceptions are answers to a complex and multifaceted situation that emphasise some correlations and advocate for certain solutions while disregarding others. When changes are necessary in social structures, communities, and populations, psychiatry fails to see this and instead focuses on the person. The problems are outlined briefly.

GENDER

It is generally accepted that the gender gap is closing and that young women are more likely to commit suicide than males. Nevertheless, in our patriarchal culture, gender justice concerns, which are typically the impetus for such endeavours, are not the focus of interventions. The effort to combat religious and cultural norms that hold women and girls in lower regard is frowned upon and is seldom supported monetarily or politically.

AGE

Suicide rates are much higher among the elderly, notwithstanding the current emphasis on suicide among young people. The Indian government formerly provided for its residents' elderly, but the burden of doing so has been transferred to the citizens' children and heirs under the country's new legislation. Many elderly individuals are left alone and poor due to the widespread absence of pensions and social security, as well as the breakdown of the traditional nuclear family, creating an environment conducive to suicide. Additionally, the law is seldom employed to provide justice and financial stability for the elderly, despite noble intentions. Persons with alcohol dependence are at increased danger of taking their own lives. However, many see such usage as immoral. It's an excuse that diverts attention from the reality that governments are dependent on tax income from alcohol sales and are seldom blamed for the nation's alarmingly high suicide rate.

FARM SUICIDE

Farmer suicides have drawn attention to the industry-wide food shortage. The development of commercial crops in formerly subsistence-focused semi-arid areas is acknowledged in the discussion. However, issues are made worse by the erratic monsoon, insufficient irrigation, indifference of government, rising expenses of farming, heavy use of fertilisers and pesticides, low pricing for agricultural products, stress in families, and addiction. Private lenders, who sometimes supply debt and death traps in addition to seeds, fertiliser, and pesticides, have risen in popularity since mainstream banks have drastically reduced agricultural loans.

SALE OF PESTICIDES

Suicide by pesticide ingestion is all too prevalent. It has prompted studies on the efficacy of pesticide banks (i.e., a secured central storage facility) and safer ways of storage (such as a double-locked box) in reducing impulsive suicide attempts and fatalities. However, this ignores the reality that multinational firms sell and make readily accessible in India very toxic chemicals that have been outlawed in nations

with higher per capita incomes. These methods place the onus of suicide prevention on people rather than on corporations that stubbornly cling to ineffective methods in the sake of profit maximisation. The usage of class II chemicals ensures continuous mortality from pesticide poisoning, even as selective techniques, including the restriction of deadly WHO class I organophosphorus insecticides, have reduced hospital admissions in Sri Lanka.

LIFE SKILLS EDUCATION

In order to teach individuals resilience and stress management techniques, many professionals have recognised the need of teaching these subjects in high school. On the other hand, Indian schools still put a premium on textbook knowledge. There is often an increase in suicide and suicide attempts during the months leading up to major exams because kids who don't fit the mould have so much trouble dealing with the pressure to succeed. The old examination methods continue to measure memorization, thus changes in the curriculum, when they occur, have little effect.

DISEASE VERSUS DISTRESS

Unlike popular belief, the great majority of persons who commit suicide are not suffering from a serious mental disease, according to recent studies conducted in India. However, psychiatric disease models that rely on symptom tally without context medicalize all forms of individual and societal suffering. People experiencing societal and emotional anguish are given psychiatric designations, despite the fact that these people's situations are ignored. When this method is used mechanically, it raises the rate of occurrence of mental problems in all contexts. Primary care providers and neuroscientists both have cast doubt on the accuracy of mental diagnoses until more is known about them.

HOLISTIC CARE

The biopsychosocial paradigm, which is emphasised in psychiatry, calls for evaluations and treatments that take into account not just the biology but also the psychological and social aspects of mental illness. However, the reductionist biomedical model, with its primary emphasis on pharmacological medication, is what is actually practised, despite the fact that the biopsychosocial approach is often praised but rarely implemented due to the lack of expertise in psychological therapy and the fact that social interventions are outside the psychiatrist's therapeutic armamentarium.

HELP SEEKING

Many people in need of emotional support turn to a wide range of potential providers: medical professionals, traditional practitioners, and religious leaders, all of whom offer a dizzying array of services based on sometimes-conflicting philosophies, theoretical frameworks, and therapeutic approaches. Telephone counselling helplines (such as 'Sneha' in Chennai) are also available in several major cities. However, studies have shown that these therapies have no effect on the suicide rate, even while they benefit many individuals who are having suicidal thoughts.

TRAINING

When in emotional pain, many people turn to their doctors; emergency rooms and critical care units encounter a high volume of people who have attempted suicide. However, in practise, psychiatric education in India remains mostly theoretical. There is a severe lack of people who can detect and effectively treat suicide risk. Similarly, there is little effort made to provide gatekeepers (e.g., educators, corrections officers, traditional healers, religious leaders, etc.) with the knowledge they need to spot those most at risk. A thorough education programme is essential not only for the transmission of information but also for the

development of necessary competence and confidence in order to recognise distress, identify suicide risk, provide psychosocial support, advise, and manage mental diseases and drug dependency. The effectiveness of such initiatives is diminished by the inability to expand them to the national level.

LEGAL ISSUES

Recent legislation, the Mental Health Act of 2017, decriminalises suicide attempts and promotes mental health services. Despite the prevalence of domestic abuse and caste-based discrimination as root causes of severe mental anguish, these situations are seldom handled in accordance with the law.

ECONOMIC SYSTEM

Suicide rates seem to be much higher in countries experiencing economic transformation (such as Russia, Ukraine, Estonia, Latvia, and Lithuania) compared to those with stable markets. 24 Yet, discussions about the economy are always centred on the GDP, while the Human Development Index is ignored. Inequality within countries, as measured by the Gini coefficient, is seldom brought to light. India has institutionalised structural violence, as seen by the mass relocation of its people from their traditional lands in the name of development projects, as well as by the widespread prevalence of rural poverty, joblessness, and urban migration. These days, governments, bureaucracies, and the upper classes are so bewitched by capitalism that social safety nets and universal healthcare are hardly discussed in the context of social justice.

CULTURE

Suicide has a negative connotation in Indian society, yet it is acknowledged as a viable choice for those experiencing unbearable emotional pain. The resolution of family conflicts is frequently shown in Indian films as a result of a character's nonfatal suicide attempt. The general public has a somewhat positive view of suicide as a means of coping with personal, social, and economic pressures. Suicide is seen as a result of several causes, including poverty, lack of empowerment, a materialistic culture, and an ineffective social and economic support system. Considerable effort should be put into elucidating the many societal and economic factors that influence and amplify suicide rates. It will need deliberate efforts to modify local attitudes and remove people's mental images of subtle cultural sanction.

RELIGION AND PHILOSOPHY

Subtle and not-so-subtle shifts in the national philosophy and attitude have emerged from the contemporary attraction and adoption of capitalistic systems of thinking and economics, which worships material prosperity. The old philosophy, religions, and culture of India, which frequently promote simple and austere lives, seem to be able to adapt, compromise, and compartmentalise India's route to modernity. Reduced conventional support structures, brought about by the focus on autonomy, contribute to increased social isolation. Many people are left without social networks as a result of rapid urbanisation and widespread migration from rural regions.

POLITICS

A heated discussion was triggered by the publication of the NCRB 2013 results and a reaction from a Union minister who placed blame on love affairs and erectile dysfunction. 26 Political viewpoints colour the reaction to suicide, and these viewpoints are often used to deflect responsibility and earn political points rather than address the problem head-on.

MEDIA

The mass and social media's extensive reach has the potential to improve people's education, perspective, and behaviour in regards to suicide and suicide attempts. However, because to the 24 hour news cycle and the importance placed on television ratings, coverage of suicide-related topics is common in the media. Many media reports on suicides focus excessively on the gory details, which might inspire imitators among the most susceptible populations. Even though self-restraint has positive effects, people often break the restriction on such message that is recommended.

NEED FOR A COMPREHENSIVE APPROACH

Multiple variables may contribute to an individual's vulnerability to suicidal ideation and behaviour, and suicide is often the last resort for those who have struggled with these issues for some time. Additionally, neither a single risk factor nor a single condition stated is adequate to account for suicide. As a result, there is no easy or foolproof way to curb suicidal thoughts. While reducing one risk factor or a cluster of linked variables may lower mortality rates for certain individuals, this may not be the case for the community as a whole. Because of this, we need a multidisciplinary, interdisciplinary strategy to prevent suicide. Simplifying suicide into a mental health issue or medical problem won't cut it. Consistent data suggests that a higher quality of living is associated with longer life expectancy and better health outcomes. Efforts to better the health of a population need a wide range of perspectives and resources beyond those only medical, including political, economical, social, cultural, engineering, scientific, educational, religious, and legal considerations. The public health approach integrates knowledge from several fields, hence it cannot be considered a discrete academic study in and of itself. Because of the wide variety of disciplines at play and the large number of stakeholders and players, the situation is complicated by the use of numerous frameworks, languages, and cultures. The medical community and pharmaceutical companies support the biomedical paradigm and curative therapies. Institutions of finance defend and insist upon the capitalist paradigm, which puts profit above the health of the populace. There is a lack of attention paid to the social sciences. Political leaders who want to stay in power often use catchy campaign rhetoric. Planning, budgeting, and goals are the main focuses of government workers. Although numerous academic fields focus on public health, their various theoretical frameworks show that they pursue very different goals.

SUICIDE AND PUBLIC HEALTH

Major issues connected to ownership of the public health aim contribute to the abysmal state of public health in India and other low- and middle-income nations. Right now, medicine has ownership of the mission but is unable to deliver, and other fields lack the motivation to take on the challenge. Different conceptualization is required in the realm of public health. Distinguishing public health as a field, an endpoint, an agenda, and a method of practise is essential. All problems should be examined through the lens of public health, and it is important to recognise the existence of power imbalances among various stakeholders and actors. Instead of being housed in the medical field, public health belongs in the realms of politics and social action. There must be a mass movement that treats concerns of public health as human rights. The difficulty is in figuring out how to combine public health aims with many theoretical paradigms. Chronic poverty contributes to the poor health of people in the world's poorest nations by limiting their ability to meet their basic requirements and limit their use of health care services, as well as via social discrimination, economic uncertainty, and political marginalisation. Many of these socioeconomic, cultural, and demographic factors are also linked to suicide, highlighting the need for population-based interventions. A strong safety net, supplied by the government, is essential due to the prevalence of several variables that increase the likelihood of suicide.

Many vulnerable people would be pushed over the edge into suicidal depression if they didn't have access to some kind of social security. Water, food, shelter, medical care, education, and job are all necessities for the equitable society envisioned by India's constitution. It should also provide equality for women and prevent people from being left out of society.

The medical and psychiatric treatments now proposed are wholly insufficient for the goal of lowering suicide rates; without such public health measures, suicide prevention would stay on paper. Population-wide public health initiatives are necessary to lower suicide rates because of the complexity of issues like suicide.

CONCLUSION

The elephant in the room is seldom addressed during India's annual ceremonial discourse on suicide. The suicide rate in India is quite high. Experts, like the blind men of Hindustan, see just what is directly in front of them because they are constrained by their disciplines and can only see what is directly relevant to them. These explanations focus on a subset of suicides, explain why those deaths occurred, and provide oversimplified approaches to a complex societal and individual problem. They It is hard to find a single, effective remedy since many of the risk factors for suicide are neither sufficient nor required for death. A suite of macroeconomic policies that mitigate the effects of free markets, programmes that address fundamental human requirements and rights, psychosocial interventions that coordinate community-based aid, a list of essential pesticides that does not include toxic chemicals, gender equality, free and accessible primary healthcare for all, legal and social safeguards for the most vulnerable, and widespread public education and information are all necessary for a lasting solution. Some nations have seen a decrease in suicide rates, although this is likely due to general social trends and rising living standards rather than any intentional efforts to reduce suicide. Although there may be evidence of a decrease in suicide rates at certain places or due to particular treatments, this is inconclusive at best. Any hope of success requires the implementation of a comprehensive national plan that employs a number of different methods.

It is important to have the foresight to realise that suicide is a final common pathway for many different types of people who turn to this extreme option when confronted with challenging life situations stemming from the sociocultural, political, and economic environment in which they find themselves. People are affected differently by the rates of sociocultural and economic change within society because of their unique histories, experiences, settings, and possibilities. Those who have the foresight to grasp the broad picture, to eliminate inequality, and to give assistance for those who began with contextual disadvantages seldom fight for comprehensive national answers that may help India bring all of its people to a more affluent future.

- **Novelty of the Study:**
  This Chapter highlights the novelty of examining suicide as a complex phenomenon influenced by environmental, sociocultural, economic, and political factors, moving beyond the traditional reductionistic biomedical model. It emphasizes the limitations of psychiatry's curative approach in addressing long-term suicide patterns and advocates for a paradigm shift towards public health measures that consider the broader sociocultural and materialist contexts. By integrating materialist theory, which attributes health outcomes to external factors, this study provides a compelling framework for understanding the persistence of suicide trends and proposes a holistic, population-level approach to suicide prevention, making a significant contribution to the discourse on mental health and public policy.
- **Future Scope:**
  The future scope of this study lies in exploring holistic, multidimensional strategies for suicide prevention that integrate public health approaches with mental health frameworks, focusing on addressing the broader sociocultural, economic, and political factors influencing suicide. Further research should aim to evaluate the effectiveness of current policies, develop community-based interventions, and investigate region-specific risk factors, particularly in vulnerable populations. Advancing the use of technology for mental health support, fostering multisectoral collaborations, and examining the legal

and ethical dimensions of suicide prevention can contribute to more comprehensive and sustainable solutions. Additionally, longitudinal studies and materialist perspectives can offer deeper insights into evolving suicide patterns and the impact of external factors on mental health outcomes in India.

♠ References :

1. World Health Organization. (2014). *Preventing suicide: A global imperative*. Geneva: WHO. Retrieved from http://apps.who.int/iris/bitstream/10665/131056/1/9789241564779_eng.pdf?ua=1 (Accessed May 10, 2016).
2. World Health Organization. (2008). *mhGAP Mental Health Gap Action Programme: Scaling up care for mental, neurological, and substance use disorders.* Geneva: WHO. Retrieved from www.who.int/mental_health/evidence/mhGAP/en/ (Accessed May 10, 2016).
3. World Health Organization. (2013). *Mental health action plan 2013–2020*. Geneva: WHO. Retrieved from http://apps.who.int/iris/bitstream/10665/89966/1/9789241506021_eng.pdf?ua=1 (Accessed May 10, 2016).
4. World Health Organization. *SUPRE Prevention of suicidal behaviours: A task for all.* Retrieved from www.who.int/mental_health/prevention/suicide/information/en/ (Accessed May 11, 2016).
5. Bertolote, J. M., Fleischmann, A., De Leo, D., Phillips, M. R., Botega, N. J., Vijayakumar, L., et al. (2010). Repetition of suicide attempts: Data from emergency care settings in five culturally different low- and middle-income countries participating in the WHO SUPRE-MISS Study. *Crisis, 31*(4), 194–201. https://doi.org/10.1027/0227-5910/a000051. https://doi.org/10.1027/0227-5910/a000051
6. National Crime Records Bureau. (2008). *Accidental deaths and suicides in India.* New Delhi: Ministry of Home Affairs, Government of India. Retrieved from http://ncrb.gov.in/adsi2013/ADSI-2013.pdf (Accessed September 29, 2015).
7. Joseph, A., Abraham, S., Muliyil, J. P., George, K., Prasad, J., &Minz, S. (2003). Evaluation of suicide rates in rural India using verbal autopsies, 1994–1999. BMJ, 326(7399), 1121–1122. https://doi.org/10.1136/bmj.326.7399.1121
8. Patel, V., Ramasundarahettige, C., Vijayakumar, L., Thakur, J. S., Gajalakshmi, V., Gururaj, G., et al.; Million Death Study Collaborators. (2012). Suicide mortality in India: A nationally representative survey. *The Lancet, 379*(9834), 2343–2351. https://doi.org/10.1016/S0140-6736(12)60606-0
9. Aaron, R., Joseph, A., Abraham, S., Muliyil, J., George, K., & Prasad, J. (2004). Suicides in young people in rural southern India. *The Lancet, 363*(9415), 1117–1118. https://doi.org/10.1016/S0140-6736(04)15896-0
10. Abraham, V. J., Abraham, S., & Jacob, K. S. (2005). Suicide in the elderly in Kaniyambadi block, Tamil Nadu, South India. *International Journal of Geriatric Psychiatry*, 20(10), 953–955. https://doi.org/10.1002/gps.1370
11. Ministry of Social Justice and Empowerment, Government of India. (2007). *Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* New Delhi: Government of India. Retrieved from http://socialjustice.nic.in/oldageact.php?pageid=3 (Accessed September 29, 2015).
12. Jacob, K. S. (2010). Alcohol and public health policies in India. *National Medical Journal of India, 23*(4), 224–225.

13. Dongre, A. R., & Deshmukh, P. R. (2012). Farmers' suicides in the Vidarbha region of Maharashtra, India: A qualitative exploration of their causes. *Journal of Injury and Violence Research, 4*(1), 2–6. https://doi.org/10.5249/jivr.v4i1.74
14. 14. Hawton, K., Ratnayeke, L., Simkin, S., Harriss, L., & Scott, V. (2009). Evaluation of acceptability and use of lockable storage devices for pesticides in Sri Lanka that might assist in prevention of self-poisoning. BMC Public Health, 9(69). https://doi.org/10.1186/1471-2458-9-69
15. Vijayakumar, L., Jeyaseelan, L., Kumar, S., Mohanraj, R., Devika, S., & Manikandan, S. (2013). A central storage facility to reduce pesticide suicides—A feasibility study from India. *BMC Public Health*, 13(850). https://doi.org/10.1186/1471-2458-13-850
16. Eddleston, M., Adhikari, S., Egodage, S., Ranganath, H., Mohamed, F., &Manuweera, G. (2012). Effects of a provincial ban of two toxic organophosphorus insecticides on pesticide poisoning hospital admissions. *Clinical Toxicology, 50*(3), 202–209. https://doi.org/10.3109/15563650.2012.656594
17. Jegannathan, B., Dahlblom, K., &Kullgren, G. (2014). Outcome of a school-based intervention to promote life-skills among young people in Cambodia. *Asian Journal of Psychiatry,* 9, 78–84. https://doi.org/10.1016/j.ajp.2014.01.011
18. Manoranjitham, S. D., Rajkumar, A. P., Thangadurai, P., Prasad, J., Jayakaran, R., & Jacob, K. S. (2010). Risk factors for suicide in rural south India. **British Journal of Psychiatry,** 196(1), 26–30. https://doi.org/10.1192/bjp.bp.108.063347
19. Jacob, K. S., & Patel, V. (2014). Classification of mental disorders: A global mental health perspective. *The Lancet, 383*(9926), 1433–1435. https://doi.org/10.1016/S0140-6736(14)60638-6

Navigating the Ethical Challenges of Autonomous Weapons : Building a Framework for Responsible AI in Modern Warfare

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ABSTRACT

The rapid advancement of artificial intelligence (AI) has revolutionized military strategies, giving rise to autonomous weapon systems (AWS) capable of making decisions without direct human intervention. These technologies present serious ethical, legal, and security issues even while they promise accuracy, effectiveness, and fewer human casualties. The ethical conundrums raised by AWS are examined in this essay, including adherence to international humanitarian law, responsibility for unintended harm, and the possible deterioration of human control in life-or-death choices. It highlights the dangers of an arms race and non-state actors using AI as a weapon, which might undermine international security.

To address these challenges, the paper advocates for the development of a robust framework for responsible AI in modern warfare. This framework would include: Ethical guidelines that prioritize human rights and humanitarian principles.transparent governance practices to guarantee responsibility and adherence to global regulations. technological protections to guard against abuse and guarantee failsafe operations. In order to reduce risks and promote confidence, the document also emphasizes the value of multilateral collaboration between countries and encourages discussion on AWS regulation. This approach seeks to leverage AI's potential to improve global security while preserving human values and international stability by striking a balance between innovation and ethical responsibility.

Keywords : *Autonomous weapon systems (AWS),International humanitarian law, AI governance, Military ethics, Global security.*

1. PROLOGUE

In the modern era, technological advancements have drastically altered the landscape of warfare. Among these developments, autonomous weapons—systems that can select and engage targets without human intervention—represent both a revolutionary capability and a profound ethical challenge. The deployment of such technologies raises critical questions about accountability, legality, and the very nature of warfare. This article explores these challenges and proposes a framework for ensuring the responsible use of artificial intelligence (AI) in modern combat, drawing on insights from prominent thinkers and ethicists. The Rise of Autonomous Weapons Autonomous weapons, often referred to as "killer robots," have transitioned from science fiction to reality. These systems leverage AI and machine learning to analyze environments, identify threats, and execute operations without direct human input. For instance, drones equipped with facial recognition and swarming capabilities can independently target specific individuals or groups. Proponents argue that these systems can enhance precision, reduce collateral damage, and minimize the risk to human soldiers. However, as Dr. Noel Sharkey, an AI ethics expert, points out, "the very notion of a machine deciding who lives and who dies is fundamentally abhorrent." Autonomous weapons shift critical decision-making from humans to algorithms, potentially leading to unforeseen consequences.

2. SCOPE OF THE STUDY:

This study explores the ethical, legal, and security implications of Autonomous Weapon Systems (AWS), which are revolutionizing military strategies through artificial intelligence (AI). The scope of the study is outlined as follows:

2.1 Ethical Challenges:

- Examines the ethical dilemmas associated with AWS, including adherence to International Humanitarian Law (IHL), responsibility for unintended harm, and the erosion of human control in critical decision-making processes.
- Focuses on the impact of delegating life-and-death decisions to AI, assessing whether these systems align with humanitarian principles and human rights.

2.2 Global Security Concerns:

- Analyzes the risks of an arms race fueled by AWS development and their potential proliferation to non-state actors.
- Evaluates how these developments could destabilize international security and disrupt global peace.

2.3 Framework for Responsible AI:

- Advocates for the creation of a robust framework to address the challenges posed by AWS, including ethical guidelines, transparent governance practices, and technological safeguards.
- Emphasizes the importance of prioritizing human rights and humanitarian principles while ensuring failsafe operations and preventing misuse.

2.4 International Collaboration:

- Highlights the need for multilateral collaboration among nations to develop global regulations and foster discussions on AWS regulation.
- Stresses the role of international agreements in mitigating risks and building confidence in the use of AI-driven military technologies.

2.5 Balancing Innovation and Ethics:

- Focuses on leveraging AI's potential to improve global security while preserving human values and ensuring ethical responsibility in warfare.
- The study is intended to contribute to the ongoing discourse on AWS by providing a comprehensive framework that balances technological innovation with ethical considerations, promoting global stability and security.

3. ETHICAL DILEMMAS

3.1 Accountability and Responsibility

One of the most significant ethical challenges is determining accountability when an autonomous weapon malfunctions or causes unintended harm. In traditional warfare, soldiers and commanders can be held responsible for their actions. But with autonomous systems, responsibility becomes murky. Is it the programmer, the manufacturer, or the military operator who should be held accountable? This lack of clarity risks creating a vacuum of accountability.

Dr. Peter Asaro, a leading scholar in AI ethics, has argued that "Delegating life-and-death decisions to machines undermines the moral responsibility of human agents." Without clear accountability mechanisms, autonomous weapons could enable a culture of impunity.

3.2 Adherence to International Humanitarian Law (IHL)

International Humanitarian Law is a cornerstone of warfare ethics, emphasizing principles such as distinction, proportionality, and necessity. AWS challenge these principles by delegating life-and-death decisions to machines. Ensuring that autonomous systems can distinguish between combatants and civilians and assess proportionality in attacks is a significant ethical concern. The lack of accountability

mechanisms further complicates compliance with IHL, as responsibility for unintended harm becomes ambiguous. Mary Ellen O'Connell, a prominent legal scholar, highlights that "Machines lack the human qualities of empathy and judgment, which are essential for adhering to the laws of armed conflict." A misclassification by an autonomous weapon could result in devastating civilian casualties and violations of IHL.

3.3 Erosion of Human Control

A key ethical concern is the potential erosion of human oversight in warfare. AWS are designed to operate autonomously, making decisions faster than human operators can intervene. This raises the question of whether delegating such critical decisions to AI undermines human dignity and moral responsibility. Maintaining meaningful human control over AWS is essential to uphold ethical standards in warfare.

3.4 Unintended Harm and Bias

AWS rely on algorithms that may be susceptible to errors, bias, or malfunction. Unintended harm, such as civilian casualties or collateral damage, is a significant risk. Furthermore, bias in AI systems could lead to discriminatory targeting, exacerbating inequalities and undermining trust in these technologies.

4. GLOBAL SECURITY IMPLICATIONS OF AWS

4.1 Arms Race and Proliferation

The development of AWS has fueled an arms race among nations, with countries investing heavily in AI-driven military technologies. This competitive dynamic increases the risk of conflict escalation and reduces the potential for diplomatic resolutions. Furthermore, the proliferation of AWS to non-state actors, such as terrorist organizations, poses a severe threat to international security.

4.2 Cybersecurity Risks

AWS are vulnerable to cyberattacks, which could compromise their functionality or redirect them for malicious purposes. The potential for hackers to manipulate AWS systems highlights the need for robust cybersecurity measures to safeguard these technologies.

4.3 Destabilization of Global Norms

The unregulated use of AWS risks destabilizing existing global norms and agreements on warfare. The lack of consensus on AWS deployment and regulation could lead to fragmented international standards, undermining efforts to promote global security.

5. BUILDING A FRAMEWORK FOR RESPONSIBLE AI IN WARFARE

To address these challenges, it is essential to establish a robust framework for the development, deployment, and oversight of autonomous weapons. This framework should be grounded in ethical principles, legal norms, and technical safeguards.

5.1 Human Oversight and Control

A central tenet of responsible AI in warfare is ensuring meaningful human oversight. Human operators must remain in the loop for critical decisions, particularly those involving the use of lethal force. As ethicist Michael Horowitz asserts, "Human judgment is indispensable in ensuring the ethical use of force." One approach is to adopt the concept of "human-in-the-loop" systems, where AI provides recommendations, but a human operator retains ultimate decision-making authority. This ensures accountability and aligns with the moral principle that humans, not machines, should bear responsibility for life-and-death decisions.

5.2 Rigorous Testing and Validation

Autonomous weapons must undergo extensive testing and validation to ensure reliability and compliance with IHL. This includes simulating complex battlefield scenarios and auditing AI algorithms for biases or flaws. Joanna Bryson, a cognitive scientist and AI researcher, emphasizes that "Transparency in AI systems is crucial for identifying and mitigating risks." Open-source standards and third-party evaluations can enhance transparency and build trust in these technologies.

5.3 International Governance

The development and deployment of autonomous weapons demand a coordinated international response. Multilateral agreements, akin to the treaties on chemical and biological weapons, can establish norms and restrictions on their use. The United Nations, through initiatives like the Convention on Certain Conventional Weapons (CCW), has already begun discussions on regulating autonomous weapons.

Philosopher Nick Bostrom advocates for a precautionary approach, arguing that "The potential risks of autonomous weapons necessitate proactive regulation." Establishing global norms and enforcement mechanisms can prevent an arms race and promote ethical standards.

5.4 Ethical AI Design

Integrating ethical considerations into AI design is essential. This includes programming autonomous systems to prioritize human safety, adhere to IHL, and avoid unnecessary harm. Stuart Russell, a leading AI researcher, has proposed the concept of "value alignment," where AI systems are designed to align with human values and ethical principles.

Furthermore, incorporating ethical training for AI developers and military personnel can foster a culture of responsibility and awareness.

6. THE ROLE OF MULTILATERAL DISCUSSIONS ON AWS REGULATION

The regulation of AWS requires inclusive and comprehensive discussions among nations, international organizations, and other stakeholders. These discussions should focus on:

- Defining the scope and limitations of AWS use in warfare.
- Establishing verification mechanisms to ensure compliance with international regulations.
- Promoting confidence-building measures to reduce the risk of conflict escalation.
- The involvement of diverse stakeholders, including civil society organizations and academia, is essential to ensure that AWS regulation reflects a broad range of perspectives and values.

As historian Yuval Noah Harari warns, "the real problem with AI in warfare is not its capabilities, but the decisions we make about its use." Open and inclusive discussions can ensure that these decisions reflect societal values and priorities.

7. STRICKING A BALANCE : INNOVATION AND ETHICAL RESPONSIBILITY

The potential of AI to enhance global security is undeniable. AWS can reduce human casualties, improve operational efficiency, and enable precise targeting in conflict scenarios. However, these benefits must not come at the cost of ethical responsibility and international stability. Striking a balance between innovation and ethical considerations is crucial to harness the potential of AI while safeguarding human values.

This balance can be achieved through the implementation of a comprehensive framework that integrates ethical guidelines, transparent governance practices, technological protections, and multilateral collaboration. By addressing the ethical and security challenges of AWS, the global community can ensure that AI serves as a force for good in modern warfare.

8. CONCLUSION

Autonomous weapons represent a transformative yet contentious frontier in modern warfare. While they offer potential benefits in precision and efficiency, their deployment raises profound ethical, legal, and strategic challenges. By adopting a framework that emphasizes human oversight, rigorous testing, international governance, and ethical design, we can navigate these challenges responsibly. The path forward requires a collective commitment to ensuring that AI serves as a tool for enhancing human dignity and security, rather than undermining it. As we stand at the crossroads of technological innovation and moral responsibility, the choices we make today will shape the future of warfare and humanity itself.

♠ References:

1. Sharkey, N. (2008). "Cassandra or false prophet of doom: AI as a threat to humanity."
2. Asaro, P. (2012). "On Banning Autonomous Weapon Systems: Human Rights, Automation, and the Dehumanization of Lethal Decision-Making." International Review of the Red Cross, 94(886), 687-709.
3. Boulanin, V., & Verbruggen, M. (2017). "Mapping the Development of Autonomy in Weapon Systems." Stockholm International Peace Research Institute (SIPRI).
4. O'Connell, M. E. (2010). The Power and Purpose of International Law. Oxford University Press.
5. Sharkey, N. (2011). "The Automation and Proliferation of Military Drones and the Protection of Civilians." Law, Innovation, and Technology, 3(2), 229-240.
6. Docherty, B. (2012). "Losing Humanity: The Case Against Killer Robots." Human Rights Watch Report.
7. Wallach, W. (2015). Moral Machines: Teaching Robots Right from Wrong. Oxford University Press.
8. Bryson, J. J. (2019). "The Past Decade and Future of AI's Impact on Society." Science.
9. Bostrom, N. (2014). Superintelligence: Paths, Dangers, Strategies. Oxford University Press.
10. Russell, S. (2019). Human Compatible: Artificial Intelligence and the Problem of Control. Viking Press.
11. Harari, Y. N. (2018). 21 Lessons for the 21st Century. Harper.
12. United Nations Office for Disarmament Affairs (UNODA). (2017). "The Weaponization of Increasingly Autonomous Technologies: Implications for Security and Ethics."

Artificial Intelligence: A Deep Dive into Its Ethical, Social, and Legal Implications

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ABSTRACT

With the unprecedented growth of AI in various sectors from industries to our daily life equipment, the whole world has been transformed shaping the economy of every country. This emergence not only served human the benefits, but also arose several challenges from its implications that is beyond the ethical, social, and legal issues. This rapid enhancement of AI has restructured and transfigured the system of technology, industrial sectors, and even reshape societal norms. It affects the fundamental and human rights with revolutionising how humans would interact. As AI continues to evolve, its ethical, social, and legal implications must be carefully considered. Policymakers, technologists, and society must collaborate to create frameworks that ensure AI benefits humanity while addressing its potential risks. Balancing innovation with responsible development will be key to navigating the future of AI. Thus, this paper analyses the respective implications of different genres of AI and its prospective future.

Keywords : artificial intelligence, ethics, judiciary, globalisation, cultural differentiation

INTRODUCTION

From an anthropological view, artificial intelligence is best understood as a "techno-social system," meaning that the technical aspects of AI are intrinsically and intimately connected to its social aspects. Social values and assumptions shape how we perceive, design, and use AI, as well as inform our perceptions, hopes, and fears of these technologies (Beer, 2009). The social world in which AI is embedded shapes its development and design. People invent, design, and program technical systems. The public has most often been alerted to the social aspects of AI design by dramatic problems and failures that make the news. Technologies enter a world that is already living, that is built on history, and that is shaped by economic and political structures (Jasanoff, 2017). As MIT Technology Review's Karen Hao argues, "Even the fairest and most accurate systems can still be used to infringe on people's civil liberties"(Hao, 2019). By the encounter of AI, the social, cultural, ethical, technological, and legal fields have been shaped and reconstructed. The ethical implications and social impacts of artificial intelligence are topics of compelling interest to industry, researchers in academia, and the public. Research social inequality, particularly among historically-marginalized groups (Hagerty, 2014).

AMPLIFICATION OF AI

AI improves the efficiency, accuracy, and scale of human effort in several domains. In healthcare, it also enhances diagnostic accuracy, analyses risk and personalizes treatments, frequently delivering better results than human professionals. In business, it optimizes procedures by automating processes, interpreting data for insights, and tailoring customer experiences. AI correlatively aids education by enabling personalized education, automating testing and assessment, and providing present-time feedback. In science and research, AI speeds up discoveries with complex data analysis and running advanced simulations. Even in daily life, AI amplifies convenience through smart home systems, virtual assistants, and creative tools for generating art, music, and writing. While these advancements bring remarkable benefits, they also

pose challenges, such as ethical concerns, job displacement, and the need for responsible implementation. AI technologies can be expected to take shape in distinct ways in different places. Analyses predict that AI and other new technologies will continue to benefit higher-skilled workers who can utilize creativity, problem-solving, and interpersonal skills (Bruckner, 2017). Low and medium skilled workers are expected to face downward pressures from increasingly competent machines and AI software. As AI technologies become more pervasive and their social impacts more deeply felt, we can expect a range of responses. In any given society, facial recognition technologies are likely to be embraced by some people and greeted as a threat by others. AI systems offer powerful tools of social organization and control. AI will be leveraged in many pro-social ways: from guaranteeing the integrity of elections, to increasing the efficiency of public transportation systems, to more effectively responding to natural disasters. However, AI systems can also be used for non-democratic ends, such as intensive surveillance of citizens and to intimidate activists and dissidents. AI systems are created and used in a flawed, imperfect, and unpredictable world. It is the meeting of AI technologies and the real world that demands our attention, and must be a research priority (Hagerty, 2014). This article has argued that AI systems have demonstrated a pattern of exacerbating inequality, often in the most unequal societies and particularly for the most vulnerable populations.

ETHICAL AND SOCIAL IMPLICATION OF AI

The aim of this report is to offer a broad roadmap for work on the ethical and societal implications of AI in the coming years. It is aimed at those involved in planning, funding, and pursuing research and policy work related to these technologies. We use the term 'ADA-based technologies' to capture a broad range of ethically and societally relevant technologies. A shared set of key concepts and concerns is emerging, with widespread agreement on some of the core issues (such as bias) and values (such as fairness) that an ethics of algorithms, data, and AI should focus on. Over the last two years, these have begun to be codified in various codes and sets of principles. Agreeing on these issues, values and high-level principles is an important step for ensuring that ADA based technologies are developed and used for the benefit of society. However, there are three main gaps in this existing work: (i) a lack of clarity or consensus around the meaning of central ethical concepts and how they apply in specific situations; (ii) insufficient attention given to tensions between ideals and values; (iii) insufficient evidence on both (a) key technological capabilities and impacts, and (b) the perspectives of different publics (Whittlestone, 2019).

Artificial Intelligence (AI) have far reached and often unforeseen ethical and social implications for almost every aspect of modern society. Bias in AI algorithms is a significant ethical issue that can result in unfair treatment or discrimination in areas such as hiring, lending, and law enforcement. Such biases often derive from unrepresentative training data and risk exacerbating existing social disparities. Privacy is another key concern because AI systems often involve massive amounts of personal data, leading to concerns about surveillance and misuse of data.

These are the social implications of AI that are just as big. Jobs in sectors such as manufacturing, customer service, and transportation are at risk of being replaced by automation and AI-driven systems, exacerbating economic inequalities. Moreover, the use of AI to augment human decision-making — for example, in healthcare or criminal justice — prompts fundamental questions about accountability and transparency in the event of error. At the same time, the fast growth of AI creates problems for rules and regulations, making it tough to create common ethical standards.

GLOBALISATION OF AI

A global competition in AI research is gaining speed in Europe, North America, and Asia. This includes medicine and healthcare. The latest studies show that AI can deliver remarkable results. For instance, AI has succeeded in diagnosing skin cancer, predicting emergency hospital admissions, and detecting breast

cancer—sometimes beating the skills of human radiologists. However, the biggest challenge in recent years has been to create ethical and legal guidelines for using AI in healthcare. Discussions on the social and ethical implications of AI are slowly beginning to feature in reports by governments and industries, as well as in academic research. This article takes an important step toward a deeper conversation about AI ethics worldwide. It highlights how regional differences, which have often been ignored, can help improve global discussions on the ethics of AI. The global influence of AI is defined by its adoption and integration across the world and in different industries. This global pattern is driven by research advancements, competition among nations, and the ability to address various challenges in health care, education, business, and other areas. However, this rapid growth also shows differences in access, regional differences in ethical standards, and the need for collaborative efforts to ensure responsible and equitable use around the world.

The social impacts of AI systems will be distinct in different places. The repercussions of these impacts have the potential to be widely, even globally, felt. While the negative consequences of AI systems will be felt by the most vulnerable groups first, and most directly, any amplification of social inequality can increase social instability, and put entire societies at risk (Hagerty, 2014). Therefore, even if the most troubling negative effects of AI systems are initially felt by only a small portion of a population, this does not mean that ill-effects will be contained to one social group. Any increase in social inequality carries risks for entire societies. As AI continues to evolve, its global impact will depend on how governments, industries, and communities collaborate to ensure that AI is used responsibly, equitably, and for the collective good. Balancing innovation with ethical considerations is key to its sustainable development.

AI IN INDIAN JUDICIARY

Benjamin Cardozo, in his seminal work "The Nature of the Judicial Process," articulates a nuanced understanding of how judges should approach the task of decision-making. He asserts that the judicial process is not merely a mechanical application of law but rather a complex interplay of various factors, including precedents, societal values, and the inherent biases of judges. Cardozo emphasizes that judges must navigate through ambiguities and gaps in the law, employing a combination of logical reasoning and moral considerations to arrive at just outcomes. He challenges the notion of the judge as an oracular figure who simply discovers existing laws, arguing instead that judges play a crucial role in creating law through their interpretations and decisions (Manathra, 2024).

Cardozo identifies four primary forces that influence judicial decision-making: the method of philosophy, the method of tradition, the force of social welfare, and the force of justice. He believes that effective judicial reasoning involves balancing these forces to ensure that decisions are not only legally sound but also socially relevant. By integrating philosophical principles with a keen awareness of societal needs, judges can foster a legal system that is both stable and adaptable to changing circumstances. This approach underscores the importance of context in legal interpretation, as judges must consider the broader implications of their rulings on society.

The judicial system usually faces delays and backlogs, with millions of cases left unresolved. AI can be used to enhance efficiency significantly by automating routine tasks such as document review and case management. AI can analyse past case data to predict outcomes, assist judges in making well-informed decisions, and simplify administrative workflows. It is essential to adopt a multifaceted approach to implementing Artificial Intelligence in the judicial process to ensure the successful adoption of this concept. There are eight main dimensions to consider: political acceptability, social desirability, technological feasibility, financial viability, judicial tenability, emotional acceptability, environmental sustainability, and administrative feasibility (Manathra, 2024). By offering AI-powered legal assistance, the model can empower citizens who might otherwise be intimidated or disadvantaged by the traditional judicial process.

CASE STUDY: SOCIAL CREDIT SYSTEM IN CHINA

One of the most talked-about aspects of modern life in China is the social credit system, though it is often misunderstood abroad. Many reports claim that the system ranks citizens based on political opinions and social behaviour, using data from facial recognition cameras, e-commerce, and social media platforms. However, these assumptions do not reflect reality. There is no unified national "social credit score," and neither facial recognition nor artificial intelligence is currently part of the system. Additionally, data sharing between the government and private companies is limited and governed by specific agreements.

The "social credit system" is a broad term for various programs aimed at enforcing existing laws. Its goals include building a reliable financial credit system, reducing fraud, and curbing "dishonest" practices like environmental violations and plagiarism. While some cities are experimenting with numerical scores to assess individuals and businesses, these scores are not used by the government for major social decisions.

Most Chinese citizens view the system positively, seeing it to combat fraud and improve society. Surveys suggest younger, educated urban residents are particularly supportive, likely because they benefit the most from good credit. However, perspectives from blacklisted individuals remain less documented, making it hard to fully assess the system's impact.

CONCLUSION

Thus, our analysis finds that AI can be expected to have critical social impacts around the world, and that these impacts will have significant regional variation. Likewise, perceptions and understandings of AI are likely to be profoundly shaped by cultural context. Consequently, further research will be required to make sense of the social impacts and ethical implications of emerging and future AI technologies. Also, By ensuring transparency, consistency, and impartiality in legal proceedings, the AI system can help mitigate biases and human errors that sometimes undermine trust in the judicial process. Ultimately, this innovative approach represents a pivotal step towards creating a more just and equitable society, where the rule of law is upheld, and justice is accessible to every member of the community.

♠ References:

1. Beer, D. (2009). Power through the algorithm? Participatory web cultures and the technological unconscious. *New Media & Society,* 11(6), 985–1002. https://doi.org/10.1177/1461444809336551
2. Bruckner, M., LaFleur, M., & Pitterle, I. (2017, July 31). The impact of the technological revolution on labour markets and income distribution. United Nations, Department of Economic & Social Affairs. https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/publication/2017_Aug_Frontier-Issues1.pdf
3. Ethical and societal implications of algorithms, data, and artificial intelligence: A roadmap for research. (2019). Whittlestone, J., Nyrup, R., Alexandrova, A., Dihal, K., & Cave, S. Nuffield Foundation.
4. Global AI ethics: A review of the social impacts and ethical implications of artificial intelligence. (n.d.). Hagerty, A. Dovetail Labs; École des hautes études en sciences sociales, Paris.
5. Hao, K. (2019, January 29). Making face recognition less biased doesn't make it less scary. *MIT Technology Review.* https://www.technologyreview.com/s/612846/making-face-recognition-less-biased-doesnt-make-it-less-scary/

6. Jasanoff, S. (2017). Virtual, visible, and actionable: Data assemblages and the sightlines of justice. *Big Data & Society,* 4(2). https://doi.org/10.1177/2053951717724475
7. Katz, Y. (2017, November 27). Manufacturing an artificial intelligence revolution. *SSRN*. https://doi.org/10.2139/ssrn.3078224
8. Lash, S. (2007). Power after hegemony: Cultural studies in mutation? *Theory, Culture & Society, 24*(3), 55–78. https://doi.org/10.1177/0263276407075956
9. Latour, B. (2005). *Reassembling the social: An introduction to actor-network-theory.* Oxford University Press.
10. Manathra, R. K., Sundaram, A., Sriram, & Ragavee, U. (2024). A study on judicial system and implementation of an AI-driven judicial process in India. *Vol. 44 No. 3, Jul-Dec 2024*, 14333–14345.
11. The World Economic Forum. (2019). The global risks report 2019. https://www.weforum.org/reports/*the-global-risks-report-2019*
12. With pop star as bait, China nabs suspects using facial recognition. (2018). *The Wall Street Journal*. https://www.wsj.com/articles/with-pop-star-as-bait-china-nabs-suspects-using-facial-recognition-1527004150
13. Zuboff, S. (2015). Big other: Surveillance capitalism and the prospects of an information civilization. *Journal of Information Technology*, 30(1), 75–89. https://doi.org/10.1057/jit.2015.5

Exploring Innovations in AI Shaping Transformative Sustainable Development goals: An Overview of Challenges and Opportunities

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ABSTRACT

Purpose: *The swift progress in artificial intelligence (AI) has created previously unheard-of chances to tackle the revolving Sustainable Development Goals (SDGs). With an emphasis on the benefits and difficulties they present, this paper examines how AI advancements connect with the goal of sustainable development. Examining how AI technologies can support sustainable development while reducing related risks is the aim of this study.*

Objectives: *To provide a comprehensive overview of AI's potential to drive transformative change across key areas such as health, education, climate action, and economic growth. Methodology: The study of effective AI applications, a thorough evaluation of the body of existing literature, and an examination of difficulties including governance issues, resource inequalities, and ethical dilemmas are all part of the technique.*

Findings: *While AI has the potential to hasten the achievement of the SDGs, the chapter reveals that it also presents serious obstacles, such as algorithmic biases, data privacy issues, and unequal access to technology. In order to guarantee the fair and moral use of AI-driven solutions, the study emphasises the significance of encouraging cooperation between governments, businesses, and academic institutions.*

Implications: *This study emphasises the necessity of strategic investment and policy frameworks to handle the problems of AI while maximising its revolutionary potential. In order to ensure a balanced approach to technological and societal advancement, stakeholders can use this overview as a basis to align AI developments with sustainable development priorities.*

Conclusion: *In order to fully realise AI's transformational promise while tackling its problems, this chapter emphasises the necessity of strategic policy frameworks, inclusive governance, and focused investments. In order to ensure a balanced approach to technology advancement and societal improvement, it gives stakeholders a foundation for aligning AI advancements with sustainable development agendas.*

Keywords: *Artificial Intelligence, Trends, Innovations, Opportunities, Challenges, Ethics, Privacy, Automation*

INTRODUCTION

Artificial intelligence (AI) has been widely adopted and used in a variety of sectors and private spheres throughout the last ten years. Depending on the situation and political interpretation, there are various approaches to describe artificial intelligence (Joyce et al. 2021). Artificial intelligence (AI) is the ability of a computer to do specific cognitive tasks that are unique to humans in order to solve issues and accomplish particular objectives (Nishant et al. 2020). These capabilities include the ability to perceive and comprehend information from the outside world, to use machine learning algorithms to replicate human thought, voice,

vision, and emotions, to connect with a particular environment, to solve problems, and to be creative (Kaplan & Haenlein, 2019). Sustainability considerations have recently been a key part of the scientific discourse surrounding artificial intelligence. Sustainability is the practice of living within the constraints of finite resources in physical, environmental, social, and cultural dimensions in a way that promotes the well-being of all life forms, beyond humans, into the far future (Adadi & Berrada, 2018). Additionally, sustainable development aims to promote development and advancement by bringing in new aspects of the physical, economic, environmental, or social world that enhance living standards without depleting present resources for future generations (Adadi & Berrada, 2018; Appio et al. 2021). The ideas of sustainable AI and AI for sustainability are distinguished in the literature in a complex way. Sustainable AI is mainly concerned with the longevity of its technology, whereas AI for sustainability is the application of AI to attain sustainable development objectives (Brock et al. 2018).

Sustainable AI, on the other hand, aims to develop ideas and methods that result in lower carbon emissions and more economical energy use in artificial intelligence technology advancements concerning consumption (Buolamwini & Gebru, 2018). Creating and running artificial intelligence (AI) systems in a way that supports sustainable and ecologically conscious business operations is known as "sustainable AI." Numerous AI systems employed by contemporary businesses are notorious for their detrimental effects on the environment. Sustainable development methods, however, can lessen these adverse effects (Devlin et al. 2018; Mirza et al. 2014). It is crucial to remember that sustainable AI does not imply continuing to advance artificial intelligence. Developing these technologies while preserving resources for current and future generations is the goal instead. The current study was started as a result of the growing significance of sustainability as a megatrend and the increasing frequency of discussions and disputes over artificial intelligence in a variety of industries. Thus, the following two questions were the focus of our investigation. Q1: What are the main points of interest in relation to artificial intelligence's influence on sustainable development? Q2: Which artificial intelligence techniques and tools are most frequently employed to accomplish sustainable development goals?

This chapter's discussion of artificial intelligence's (AI) function in sustainable development is motivated by the realisation that there is a plethora of data scattered throughout scholarly publications and internet sources. Although this information is useful, it only offers a partial picture of the topic. Our contribution is predicated on our research's emphasis on compiling, evaluating, and combining these disparate views from many literary streams to offer a condensed perspective that emphasises the key topics arising at the nexus of artificial intelligence and sustainable development. This contribution is especially significant at a time when policymaking and the larger social movement towards sustainable living heavily rely on the convergence of technology and sustainability (Mirza et al. 2014; Zhang et al. 2016). Artificial intelligence (AI) is being used more and more in many fields, so it's critical to evaluate how it will affect the Sustainable Development Goals. Sustainable development may be impacted by AI in both positive and bad ways (Vinuesa et al. 2020). Environmental issues including an increasing carbon impact are brought up by AI. To overcome this limitation, sustainable AI focuses on cutting emissions and energy use. The development of energy-efficient infrastructure, the application of policies, the rebalancing of the model's scale, a fresh reprioritisation of data quality and education can all help achieve these goals (Mirza et al. 2014; Zhou et al. 2023). Positively, artificial intelligence can help design new sustainable materials to monitor and predict environmental changes, compress greenhouse gas emissions, expand and implement sustainable practices in the industry, and optimise energy consumption and waste reduction. Additional advantages of AI in the medical domain include the use of smart devices to detect specific illnesses and symptoms and to detect epidemics early on (Zhou et al. 2023; Joyce et al. 2021). Artificial intelligence in agriculture offers guidance on weather forecasts, fertilisation, planting, and harvesting. Providing more effective manufacturing, distribution, and storage systems is an additional benefit.

EVOLUTION OF EMERGING TRENDS IN AI

A number of new developments are influencing the direction of AI as it develops further. These patterns show where AI technology is going and how it could affect different industries.

- **Explainable AI (XAI):** The "black box" character of many algorithms, where the decision-making process is opaque, is one of the major obstacles in AI. By offering insights into the decision-making process, explainable AI seeks to improve the interpretability and comprehension of AI systems (Karunamurthy et al. 2022). This is especially critical in industries where comprehending the reasoning behind AI suggestions is essential, such as healthcare and finance.
- **AI Ethics and Governance:** AI Ethics and Governance: Ethical issues are becoming increasingly important as AI systems proliferate. Discussions about AI are centred on concerns like accountability, privacy, and bias. Governments and organisations are developing rules and frameworks to guarantee that AI is created and used ethically. Fairness, openness, and minimising unforeseen repercussions are all part of this (Zhou et al. 2023).
- **Edge AI:** Cloud computing is frequently used for data processing in traditional AI applications (Kaplan & Haenlein, 2019). But Edge AI reduces latency and enhances real-time decision-making by moving the computation closer to the data source. For Internet of Things (IoT) applications and gadgets that need quick reactions, such driverless cars and smart cities, this trend is especially pertinent.
- **AI in Creative Industries:** AI is becoming more and more prevalent in creative industries. AI is proving to be a useful tool for artists and makers, from creating art and music to crafting poetry and creating fashion (Krizhevsky et al. 2012). These AI-powered creative tools are increasing productivity, opening up new possibilities, and boosting human creativity.
- **AI for Social Good:** AI is being used more and more for environmental and social concerns. Applications range from maximising energy use and keeping an eye on climate change to expanding access to healthcare and education in underprivileged areas. AI-powered solutions are being created to address some of the most important issues facing the globe, proving that technology can lead to constructive change (Appio et al. 2021).

EMERGING TRENDS IN ARTIFICIAL INTELLIGENCE

Our world is changing as a result of artificial intelligence (AI), which is achieving its revolutionary potential in a number of industries. This article will explore the new developments in AI that are transforming company operations, improving decision-making, and spurring creativity. These developments set the stage for a time when artificial intelligence (AI) permeates every aspect of our daily lives, from robotics and computer vision to natural language and machine learning. In the highly competitive AI market, AI companies can also gain from taking part in esteemed award programs like the Globee Awards, which offer validation and recognition.

- **Machine Learning (ML):** A new era of computing has been brought about by machine learning (ML) techniques, which allow systems to learn by analysing vast volumes of data and provide somewhat accurate predictions or judgements without the need for explicit programming (Krizhevsky et al. 2012). Image identification, language translation, and recommendation systems are just a few of the activities that have been transformed by this game-changing technology. Large-scale data processing enables ML systems to find previously unattainable complex patterns and insights (Kumar et al. 2017). This skill has improved computational processes' accuracy and efficiency and created a plethora of opportunities in industries including marketing, finance, healthcare, and more.
- **Natural Language Processing (NLP):** The goal of NLP is to make it possible for computers to understand and analyse human language. This has resulted in notable developments in chatbots, sentiment analysis, voice assistants, and language translation. These technologies improve human-machine communication, resulting in more efficient and natural interactions (Kuziemski & Misuraca, 2020).

- **Automation and Robotics:** AI-powered robots are being used more and more in industries like manufacturing, healthcare, and logistics, revolutionising procedures by improving accuracy and efficiency (Kuziemski & Misuraca, 2020; Lewis et al. 2019). These robots can optimise operational workflows by precisely completing a variety of complicated activities, from automated assembly lines to surgical procedures.
- **Computer Vision:** Applications like object detection, facial recognition, and driverless cars are made possible by computer vision algorithms, which enable machines to evaluate and interpret visual data (Madan & Ashok, 2023). Tasks involving picture and video analysis are made easier by these technologies, which give machines the ability to see and comprehend the visual environment.
- **Deep Learning:** Models of deep learning, which are modelled after the neural architecture of the human brain, are able to handle enormous volumes of data and recognise complex patterns, which have led to advances in fields like autonomous decision-making, speech synthesis, and picture recognition (Madan & Ashok, 2023; Makridakis, 2017). These models serve as the foundation for numerous cutting-edge AI applications, spurring creativity across a wide range of industries.
- **Explainable AI:** Transparency and interpretability are essential as AI systems get more sophisticated. Explainable AI seeks to increase the accountability and understand ability of AI algorithms and their conclusions so that interested parties can have faith in the results and comprehend the decision-making process (Mnih et al. 2015; Moeuf et al. 2020). Using AI models on edge devices, like wearable, smartphones, and Internet of Things (IoT) gadgets, is known as edge AI. For applications that need quick answers, this allows real-time data processing and lessens need on cloud computing, resulting in quicker and more effective inference right on the device (Moeuf et al. 2020).
- **Generative AI:** Generative AI methods, such generative adversarial networks (GANs), are capable of producing fresh text, music, and image content. These technologies have important uses in the creative industries and content creation, fostering innovation and creativity while facilitating the creation of original, high-calibre material (Nishant et al. 2020).
- **AI Ethics & Responsible AI:** As AI has a greater impact on society, conversations about ethics, bias, fairness, and responsible AI practices are taking centre stage (Piccarozzi et al. 2022). To avoid harm and advance fair results, it is crucial to make sure AI technologies are created and implemented in accordance with ethical principles.
- **AI and Healthcare:** AI is significantly advancing healthcare in areas including drug development, personalised treatment, disease detection, and patient monitoring. Through increased diagnostic precision, accelerated medication development, and individualised treatment plans catered to each patient's needs, these technologies are transforming the way healthcare is delivered (Madan & Ashok, 2023).

Artificial intelligence's new developments have the ability to revolutionise entire sectors, spur innovation, and solve difficult problems. AI has the potential to completely transform how companies run and engage with their clientele, resulting in more individualised experiences, increased productivity, and data-driven decision-making. Recognition and validation are essential for AI firms to highlight their accomplishments and set themselves apart in a competitive market as AI continues to impact our future.

CURRENT STATE OF AI AND ITS APPLICATIONS

In recent years, artificial intelligence has advanced significantly and is now a crucial component of numerous sectors. Without explicit programming, machines may learn from data and get better over time thanks to machine learning, a branch of artificial intelligence. This talent has produced innovations in a number of fields, including:

- **Healthcare Sector:** Innovation and efficiency are being driven by artificial intelligence, which is continuing to transform a number of industries. AI has greatly enhanced predictive analytics, individualised treatment plans, and diagnostics in the healthcare industry. While AI-powered chatbots offer round-the-clock patient support, sophisticated algorithms typically outperform human radiologists in their analysis of medical pictures. Additionally, predictive models are utilised to optimise hospital resource allocation and predict illness outbreaks. AI, for instance, played a key role in monitoring the COVID-19 pandemic's spread and speeding up the creation of a vaccine (Makridakis, 2017).
- **Financial sector:** AI provides individualised financial advice, automates trade, and improves fraud detection. Robo-advisors provide customised investing plans, and machine learning models identify fraudulent activity by evaluating transaction patterns in real-time Mnih et al. 2015). AI is used by businesses like JPMorgan Chase to automate procedures, enhance customer satisfaction, and optimise operations, which results in considerable cost savings and increased operational effectiveness.
- **Entertainment industry:** AI has been adopted by the entertainment sector to provide more individualised experiences. AI is used by services like Netflix and Spottily to evaluate customer preferences and suggest personalised content. AI tools are also being utilised to produce high-quality visual effects in films, write scripts, and compose music. For example, lifelike animations and special effects have been created using generative AI models, which has sped up and reduced the cost of production processes (Moeuf et al. 2020).
- **Retail Sector:** AI is revolutionising how companies handle operations and engage with clients. AI is used by e-commerce behemoths like Amazon to make product recommendations based on customer behaviour and past purchases (Nishant et al. 2020). Chatbots increase user happiness by effectively handling consumer complaints and questions. AI-powered inventory management solutions also decrease waste and maximise stock levels. AI-powered pricing tactics and virtual try-on technologies are recent developments that enable merchants to dynamically adjust to customer demand.
- **Manufacturing Sector:** By streamlining production procedures, improving quality assurance, and facilitating predictive maintenance, artificial intelligence is transforming the manufacturing sector. AI-powered systems, for instance, use sensor data analysis to forecast equipment breakdowns, which lowers maintenance expenses and downtime. AI is used by businesses like Siemens and GE to operate smart factories, increasing productivity and cutting waste. Manufacturers may now produce creative product designs that are optimised for material and performance thanks to recent developments in generative design (Piccarozzi et al. 2022).
- **Transportation and Logistics:** Through demand forecasting, route optimisation, and driverless cars, artificial intelligence is revolutionising transportation and logistics. While logistics firms like DHL and FedEx utilise AI to manage inventories and optimise delivery routes, Tesla and Waymo are leading the way in self-driving technology (Piening, 2013). Predictive analytics powered by AI aids in predicting supply chain interruptions, such as those that occur during international shipping difficulties, and guarantees that items are delivered on time.
- **Agriculture:** Precision farming, crop monitoring, and predictive analytics are some of the ways AI is increasing agricultural productivity. While machine learning models forecast weather patterns and optimise irrigation schedules, drones with AI-powered sensors assess soil health and track crop conditions. AI is incorporated into farming equipment by companies such as John Deere, allowing for real-time data analysis to optimise yields. Artificial intelligence (AI) systems that identify pests and diseases early on have reduced crop losses (Reddy et al. 2021).
- **Energy:** AI is optimising energy production, distribution, and consumption in the energy sector. In order to balance supply and demand, renewable energy firms employ artificial intelligence (AI) to forecast solar and wind energy generation. AI-powered smart grids facilitate effective energy distribution and cut down on waste. To drastically reduce energy costs, Google's DeepMind, for example, has teamed up with energy providers to increase the efficiency of data centres and power plants (Ritz, Wolf, & McQuitty, 2019).

- **Education:** Through automated grading systems, virtual tutors, and adaptable learning platforms, artificial intelligence is personalising education. AI is used by platforms such as Duolingo and Coursera to customise content according to each learner's learning preferences and development. AI chatbots offer pupils immediate assistance, and predictive analytics assist teachers in identifying students who may be at risk (Sandén & Hillman, 2011). AI-powered technologies that use virtual reality (VR) and augmented reality (AR) to create immersive learning experiences are examples of recent advancements.
- **Real Estate:** By increasing property values, expediting transactions, and improving client experiences, artificial intelligence is revolutionising the real estate industry. AI-powered chatbots help buyers and renters identify houses that fit their interests, while platforms like Zillow utilise AI algorithms to deliver realistic housing valuations (Madan & Ashok, 2023). Additionally, new market trends and investment opportunities are being found through the application of predictive analytics.
- **Public Safety and Security:** Through surveillance, crime prediction, and catastrophe response, artificial intelligence is being utilised to improve public safety. Artificial intelligence (AI)-powered facial recognition and video analytics tools assist law enforcement in recognising threats and taking prompt action. In order to efficiently distribute resources, predictive policing algorithms examine past crime data (Piccarozzi et al. 2022). Drones and robots with AI capabilities help with search and rescue operations during natural disasters, enhancing response times and results.

As a result of developments in computer vision, generative AI, and natural language processing, AI's importance is growing throughout many industries. Even with obstacles like moral dilemmas and the requirement for strong data governance, AI has a huge and bright future ahead of it.

CURRENT AND EMERGING TRENDS IN AI

Improved Natural Language Processing: In recent years, Natural Language Processing (NLP) has evolved significantly, and we can anticipate much more sophisticated capabilities. Chatbots and virtual assistants driven by AI will become more conversational and more accurate at interpreting context and intent (Madan & Ashok, 2023). Businesses will be able to streamline customer support operations and offer a personalised client experience as a result.

- **Autonomous Systems and Reinforcement Learning:** Reinforcement learning, a subfield of artificial intelligence that allows robots to learn by making mistakes, is rapidly gaining popularity (Piccarozzi et al. 2022). Robotic process automation and self-driving cars are examples of autonomous systems that will advance in sophistication and dependability. This will result in safer operations, lower expenses, and more efficiency in sectors including manufacturing, logistics, and transportation.
- **Explainable AI:** As AI spreads, there will be a greater demand for accountability and transparency. Businesses will be able to comprehend and analyse the decisions made by AI systems thanks to the growing popularity of explainable AI techniques (Lewis et al. 2019). This will be especially important in fields where ethical and regulatory compliance are critical, such as finance, healthcare, and law.
- **AI and Edge Computing:** Will edge computing which processes data closer to the source instead of depending on cloud infrastructure is more common? The requirement for reduced latency and real-time decision-making will propel this trend. Applications such as remote monitoring systems, IoT devices, and driverless cars will benefit from speedier insights and actions made possible by AI algorithms placed at the edge (Piening, 2013).
- **AI-Powered Cyber security:** AI will be essential in strengthening cyber security defences due to the growing sophistication of cyber threats. In order to spot irregularities, spot trends, and proactively counter such threats, artificial intelligence algorithms will be employed (Ritz, Wolf, & McQuitty, 2019). By protecting sensitive data and staying ahead of thieves, this will help businesses maintain customer trust and business continuity.

- **Systems for Tailored Marketing and Suggestions:** Recommendation systems driven by AI will keep developing, allowing companies to provide more customised marketing experiences. AI algorithms will produce customised recommendations, promotions, and ads by examining enormous volumes of consumer data. Conversions, customer engagement, and overall marketing effectiveness will all increase as a result (Tabrizi et al. 2019).
- **AI Ethics & Responsible AI:** As AI spreads, ethical considerations will become more crucial. Companies will concentrate on creating and putting into place frameworks for the responsible use of AI. This entails fixing algorithmic biases, guaranteeing equity and inclusivity, and creating rules for AI governance (Reddy et al. 2021). Businesses that place a high priority on moral and responsible AI practices will reduce risks and gain the trust of stakeholders and customers.

PREDICTIONS FOR THE NEXT DECADE

AI will transform industries by enabling more intelligent energy solutions, individualised healthcare, and sophisticated automation. Bias and data privacy are two ethical issues that will become more pressing. Advances in robotics and natural language comprehension will change daily life, and cooperation and governance in AI will be essential to guaranteeing benefits are distributed fairly among international communities;

- **Integration with Daily Life:** As smart assistants and AI-powered gadgets become standard fixtures in homes and offices, artificial intelligence will become increasingly more ingrained in our daily lives. AI will greatly increase convenience, efficiency, and quality of life in a variety of ways, from smart houses that anticipate and react to human needs such as regulating the temperature and lighting to individualised AI tutors that improve educational experiences (Karunamurthy et al. 2022).
- **Developments in Natural Language Processing (NLP):** NLP is expected to see significant developments that will allow AI systems to comprehend and produce human language more accurately and nuanced (Madan & Ashok, 2023). This will expedite commercial processes through improved communication tools, revolutionise customer service by offering more effective and sympathetic help, and make virtual assistants more user-friendly and intuitive, enabling smooth human-AI interactions.
- **AI and Human Collaboration:** The dynamics of collaboration between AI and humans will grow significantly in the future. The use of augmented intelligence, in which AI technologies assists people in making better-informed and more effective decisions will grow in popularity (Piccarozzi et al. 2022). This mutually beneficial partnership will use the advantages of AI's data processing skills and human ingenuity, producing better results across a range of industries, including healthcare and finance.
- **AI in Scientific Discovery:** AI will play a key role in quickening the rate of scientific discoveries and research. It will be essential in many fields, including drug development, genomics, space exploration, and climate modelling, enabling researchers to tackle difficult problems, examine enormous amounts of data, and find novel insights that would be hard or impossible to obtain using only conventional techniques (Vinuesa et al. 2020).
- **Ethical AI by Design:** As the ethical ramifications of AI become more widely recognised, more attention will be paid to creating AI systems that are by their very nature just, open, and responsible (Appio et al. 2021). Every phase of AI development will incorporate ethical standards to guarantee that these technologies are created to advance equity, protect human rights and dignity, and benefit society as a whole.

CHALLENGES AND ETHICAL CONSIDERATIONS

Notwithstanding its potential benefits, AI presents drawbacks such as algorithmic bias, worries about data privacy, and the possibility of employment displacement. Ensuring accountability, transparency, and fair access are all ethical considerations. While using AI improperly for spying or disinformation jeopardises public trust, autonomous decision-making presents ethical quandaries. Resolving these problems is essential for ethical AI.

- **Fairness and Bias:** AI systems are susceptible to biases found in the datasets they were trained on, which may result in discriminating and unfair decision-making processes. This is particularly important in fields where biased decisions can have major practical effects, such as recruiting, lending, and law enforcement (Karunamurthy et al. 2022; Krizhevsky et al. 2012). In addition to recognising and reducing pre-existing biases, maintaining fairness requires regularly assessing and updating models to stop the emergence of new biases.
- **Security and privacy:** AI systems frequently use enormous volumes of data, a large portion of which may be sensitive or personal. Due to the possibility of data breaches or misuse, this presents serious privacy concerns. Implementing strict data protection measures, such as encryption, access limits, and frequent security audits, is necessary to ensure data security. Concerns around the collection, storage, and sharing of data must also be addressed in order to safeguard people's right to privacy (Joyce et al. 2021).
- **Job displacement:** AI technologies have the potential to significantly reduce employment in a number of industries by automating jobs that have historically been completed by humans. AI threatens existing jobs even if it has the ability to generate new ones, especially in industries like manufacturing, logistics, and customer service (Buolamwini & Gebru, 2018). The creation of policies and initiatives centred on workforce transitions, reskilling, and up skilling to equip the workforce for new positions in an AI-driven economy is crucial to reducing these effects.
- **Accountability:** As artificial intelligence (AI) systems get more involved in decision-making, it becomes more difficult to assign blame for decisions and acts. It is challenging to assign blame when mistakes or negative results occur because AI systems are independent and lack transparency (Madan & Ashok, 2023). In order to address accountability and liability, it is imperative to establish explicit norms and procedures. This will guarantee that there are methods for monitoring, restitution, and accountability for the decisions and actions made by AI systems (Reddy et al. 2021).

Artificial intelligence has a fascinating and complicated future. AI technologies have the ability to change industries, enhance our daily lives, and solve global issues as they develop further. To fully realise this potential, though, ethical issues must be resolved, justice must be upheld, and cooperation between humans and machines must be encouraged. Through careful consideration of these obstacles, we can leverage AI's potential to improve everyone's future.

LIMITATIONS AND DIRECTIONS FOR FUTURE STUDY

There are certain limitations to the study that point to potential directions for further investigation. First, there are certain issues with the SD approach utilised for prediction because it is based on a simulation model. Therefore, previous research on the subject should be taken into consideration when interpreting the results of this study. Empirical research should also be used in future studies to produce factual findings. Second, this study has certain limited concept. Therefore, I advise future research to replicate AI-driven breakthroughs in other nations, particularly ones with lower SDG effort, in order to gain a deeper understanding of them. Third, the study is carried out in a variety of nations with differing political systems and degrees of development. As a result, extrapolating the findings to other nations or areas can be challenging. Future studies should focus on particular countries and assess more thoroughly how AI-based innovation affects SDG achievement locally. Fourth, the study only looks at the macro-level implications of AI-based innovation on SDGs; future studies should look into the micro-level effects as well, such how it affects specific homes and communities. The qualitative insights indicated above should be included in future research; I have not taken into account the recursive linkages between results, institutional arrangements, enacted technology, and organisational forms. These cyclic interactions ought to be examined in future research on the relationship between AI,

innovation, and SDGs. To put it another way, future studies should look into the ways that SDGs can spur AI-based innovation as well as any potential obstacles to this relationship. Seventh, future studies ought to take into account how the SDGs are interconnected and how innovations based on AI may have an impact on other SDGs.

CONCLUSION

Automation and artificial intelligence are drastically changing the commercial and technological landscape. As we've seen, companies are now able to innovate, boost productivity, and streamline operations in previously unthinkable ways thanks to AI-powered automation technologies. Examples of how AI and automation are transforming businesses include the emergence of AI in various business processes, the function of machine learning in automation, and the idea of robotic process automation. By incorporating human-like cognitive abilities, cognitive automation is also enhancing AI-powered systems. Artificial Intelligence (AI) in Information Technology (IT) presents a number of opportunities that have the potential to transform industries and improve human life. AI's automation, efficiency, and customised user experiences are revolutionising customer interactions and company operations. However, AI presents important issues that must be resolved, just like any other game-changing technology. For AI to be integrated into society responsibly and sustainably, ethical concerns, possible labour disruptions, data quality problems, and the creation of suitable legislative frameworks must all be properly managed. Collaboration amongst different stakeholders, such as researchers, industry leaders, and legislators, is crucial to maximising the potential of AI in IT. We can create the foundation for a future in which artificial intelligence enables people to make incredible strides in the digital age by proactively addressing these issues and utilising AI's potential.

But it's critical to recognise the possible difficulties. There have been concerns expressed regarding the ethical implications of AI-driven automation as well as employment displacement. Businesses will need to adjust and make sure that employees have a seamless transition as they continue to accept this shifting landscape. With new developments and possible uses in the works, the future of automation and artificial intelligence is bright. Companies will stay competitive and prosper in this changing environment if they use AI technology and automation solutions in their digital transformation initiatives. To sum up, automation and artificial intelligence are here to stay, so it's critical for companies to stay on top of the latest developments. Businesses can fully utilise AI and automation to spur innovation and stay ahead of the curve with the correct tactics and mind-set.

♠ References:

1. Adadi, A., & Berrada, M. (2018). Peeking inside the black-box: a survey on explainable artificial intelligence (XAI). *IEEE access,* 6, 52138-52160.
2. Appio, F. P., Frattini, F., Petruzzelli, A. M., & Neirotti, P. (2021). Digital transformation and innovation management: A synthesis of existing research and an agenda for future studies. *Journal of Product Innovation Management,* 38(1), 4-20.
3. Brock, A., Donahue, J., & Simonyan, K. (2018). Large scale GAN training for high fidelity natural image synthesis. arXiv preprint ar*Xiv:1809.11096.*
4. Buolamwini, J., & Gebru, T. (2018). Gender shades: Intersectional accuracy disparities in commercial gender classification. In *Conference on fairness, accountability and transparency* (pp. 77-91). PMLR.
5. Devlin, J., Chang, M. W., Lee, K., & Toutanova, K. (2018). Bert: Pre-training of deep bidirectional

transformers for language understanding. arXiv preprint *arXiv:1810.04805*.

6. Goodfellow, I., Pouget-Abadie, J., Mirza, M., Xu, B., Warde-Farley, D., Ozair, S., ... & Bengio, Y. (2014). Generative Adversarial Nets. Advances in Neural Information Processing Systems, 27.
7. He, K., Zhang, X., Ren, S., & Sun, J. (2016). Deep residual learning for image recognition. In *Proceedings of the IEEE conference on computer vision and pattern recognition* (pp. 770-778).
8. Ji, Z., Zhou, T., & Zhang, Q. (2023). The impact of digital transformation on corporate sustainability: Evidence from listed companies in China. *Sustainability, 15*(3), 2117.
9. Joyce, K., Smith-Doerr, L., Alegria, S., Bell, S., Cruz, T., Hoffman, S. G., & Shestakofsky, B. (2021). Toward sociology of artificial intelligence: A call for research on inequalities and structural change. *Socius*, 7, 2378023121999581.
10. Kaplan, A., & Haenlein, M. (2019). Siri, Siri, in my hand: Who's the fairest in the land? On the interpretations, illustrations, and implications of artificial intelligence. *Business horizons*, 62(1), 15-25.
11. Karunamurthy, A., Kulunthan, K., Dhivya, P., & Vickson, A. V. S. (2022). A Knowledge Discovery Based System Predicting Modelling for Heart Disease with Machine Learning. *Quing: International Journal of Innovative Research in Science and Engineering*, 1(1), 14-22.
12. Krizhevsky, A., Sutskever, I., & Hinton, G. E. (2012). Imagenet classification with deep convolutional neural networks. *Advances in neural information processing systems,* 25.
13. Kumar, R., Sharma, A., Siddiqui, M. H., & Tiwari, R. K. (2017). Prediction of human intestinal absorption of compounds using artificial intelligence techniques. *Current drug discovery technologies,* 14(4), 244-254.
14. Kuziemski, M., & Misuraca, G. (2020). AI governance in the public sector: Three tales from the frontiers of automated decision-making in democratic settings. *Telecommunications policy*, 44(6), 101976.
15. Lewis, G. A., Bellomo, S., & Galyardt, A. (2019). Component mismatches are a critical bottleneck to fielding AI-enabled systems in the public sector. *arXiv preprint arXiv:1910.06136.*
16. Madan, R., & Ashok, M. (2023). AI adoption and diffusion in public administration: A systematic literature review and future research agenda. *Government Information Quarterly,* 40(1), 101774.
17. Makridakis, S. (2017). The forthcoming Artificial Intelligence (AI) revolution: Its impact on society and firms. *Futures,* 90, 46-60.
18. Mnih, V., Kavukcuoglu, K., Silver, D., Rusu, A. A., Veness, J., Bellemare, M. G., ... & Hassabis, D. (2015). Human-level control through deep reinforcement learning. *nature*, 518(7540), 529-533.
19. Moeuf, A., Lamouri, S., Pellerin, R., Tamayo-Giraldo, S., Tobon-Valencia, E., & Eburdy, R. (2020). Identification of critical success factors, risks and opportunities of Industry 4.0 in SMEs. *International Journal of Production Research,* 58(5), 1384-1400.
20. Nishant, R., Kennedy, M., & Corbett, J. (2020). Artificial intelligence for sustainability: Challenges, opportunities, and a research agenda. *International Journal of Information Management, 53,* 102104.
21. Piccarozzi, M., Silvestri, C., Aquilani, B., & Silvestri, L. (2022). Is this a new story of the 'Two Giants'? A systematic literature review of the relationship between industry 4.0, sustainability and its pillars. *Technological Forecasting and Social Change,* 177, 121511.
22. Piening, E. P. (2013). Dynamic capabilities in public organizations: A literature review and research agenda. *Public management review,* 15(2), 209-245.
23. Reddy, M. D. M., Basha, M. S. M., Hari, M. M. C., & Penchalaiah, M. N. (2021). Dall-e: Creating images from text. *UGC Care Group I Journal,* 8(14), 71-75.

24. Ritz, W., Wolf, M., & McQuitty, S. (2019). Digital marketing adoption and success for small businesses: The application of the do-it-yourself and technology acceptance models. *Journal of Research in interactive Marketing,* 13(2), 179-203.
25. Sandén, B. A., & Hillman, K. M. (2011). A framework for analysis of multi-mode interaction among technologies with examples from the history of alternative transport fuels in Sweden. *Research policy,* 40(3), 403-414.
26. Tabrizi, B., Lam, E., Girard, K., & Irvin, V. (2019). Digital transformation is not about technology. *Harvard business review,* 13(March), 1-6.
27. Vărzaru, A. A. (2022). An empirical framework for assessing the balanced scorecard impact on sustainable development in healthcare performance measurement. *International Journal of Environmental Research and Public Health,* 19(22), 15155.
28. Vinuesa, R., Azizpour, H., Leite, I., Balaam, M., Dignum, V., Domisch, S., & Fuso Nerini, F. (2020). The role of artificial intelligence in achieving the Sustainable Development Goals. *Nature communications,* 11(1), 1-10.
29. Winkelhake, U. (2019). Challenges in the digital transformation of the automotive industry. *ATZ worldwide,* 121(7), 36-43.
30. Zavrazhnyi, K., & Kulyk, A. (2023). Comparative characteristics of the managerial and economic aspects of digital business transformation. *Економіка розвитку систем,* 5(2), 27-32.

Artificial Intellignce a Boost-up Associate for Startups In India : An Outline

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ABSTRACT

India's startup culture is diverse and innovative. In India, startups working on a wide range of areas, such as agriculture, health, education, fintech etc. The diversity of startups reflects the country's rich culture and linguistic diversity. In many industries including startups Artificial Intelligence (AI) has been swiftly incorporated by solving real problems through insights and automation. AI's vast potential continues to gain recognition in different sectors. Due to vast ability like learning, thinking, problem-solving and decision making process Artificial intelligence is known as an umbrella.

Keywords: *Fintech, AI, Innovation, Startups.*

INTRODUCTION

India's startups have rapidly changes from last decade. Despite global economic and regulatory challenges startups become a driving force of an entrepreneurial spirit. India became now one of the largest economies in world. The future of startups in India looks promising. Startup culture in India refers to the establishment of new businesses in different sectors. To promote entrepreneurship and provide employment opportunities is the main idea behind startups. The central government is also working to create a positive ecosystem for startups. Successful startups depend on some factors like large market, a fast growing economy, government support, innovative startup culture etc. All the factors are equally strong in Indian business culture. Artificial intelligence (AI) is already the main driver of emerging technologies like robotics, big data etc. AI has a long history. After the development of machine learning and deep learning, IBM's Deep Blue defeated chess master Garry Kasparov in 1997 and the company's IBM Watson won Jeopardy in 2011.

LITERATURE REVIEW

Govindarajan (2019) explained that in today's environment artificial intelligence companies are spending billions of dollars just to stay relevant. Artificial intelligence and machine learning is the most compelling, disruptive and terrifying technology trends today. This article highlighted about the role of artificial intelligence in startups.

Mohanty (2019) revealed that artificial intelligence based analysis is used by these startups to make data driven decisions. Artificial business analytics can play a very crucial role in the overall success of startup organization. Startups are taking advantage of artificial intelligence because it enables them to provide their customers with personalized marketing, which in turn increases engagement, helps to enhance customer loyalty and improve sales, saves time and money by automating and optimizing routine processes and tasks.

Sreenivasan and Suresh (2022) focused that technological and inventive startups have shown a powerful capacity to evolve and modify to global pandemic episodes and other challenges. This study proposes a review on the adoption of artificial intelligence in startups.

Yaranal and Arvinda (2023) observed that in India, artificial intelligence has experienced substantial development. Artificial intelligence has seen remarkable in innovations and also used in cutting edge technology. This article discussed a brief overview of the development of Indian artificial intelligence businesses while recognizing their importance in the larger tech community.

Ganeshan et Al (2023) discussed that the artificial intelligence can greatly benefit entrepreneurs and startups through human resource management in several ways like diversity and inclusion, data security, predictive analytics etc. Artificial intelligence can enhance productivity and efficiency, ultimately inspiring more creativity. This article focused on artificial intelligence that can help entrepreneurs and startups optimize their human resource processes and improve decision making.

Pati et Al (2024) explained that artificial intelligence integration affects several facts of startup performance, including market competitiveness, innovation and growth. This study focusing on the Indian startup environment and artificial intelligence performed in advancing sustainable business practices, boosting economic growth and improving entrepreneurial success. Artificial intelligence can be leveraged effectively to address processing social and environmental challenges, ultimately contributing to a more equitable and prosperous society.

OBJECTIVES

- To analyze the effect of artificial intelligence in startups.
- To analyze the impact of startups in recent economy.

SIGNIFICANCE OF THE STUDY

Startups have played a significance role in the growth, innovations and sustainability. Artificial intelligence baaed startups is catalyst in job creation and solving everyday problems. In recent days we have seen that many startups like Flipkart, Zomato, In-drive generated many employment for the youth.

METHODOLOGY

In India, startup sectors impacted huge in innovations sustainability and growth. In Indian economy startups gives a huge transformation. This study basically highlighted on artificial intelligence and startups in Indian economy. The study is based on the secondary data, which has been collected through books, magazine, journals, newspapers, research articles, websites etc.

KEY EFFECTS OF ARTIFICIAL INTELLIGENCE IN STARTUPS

A) Improved decision making: AI enhances decision making process quickly by analyzing complex data sets. Artificial intelligence has ability to handle large datasets and extract insights in real time gives companies an advantage in data driven strategic planning. Business leaders and officials face increasing pressure to make the proper decisions in the officeplace.

B) Increased operational efficiency: Artificial intelligence can help businesses achieve unprecedented levels of productivity, efficiency and innovation. AI increased productivity and efficiency and also cost savings and reduced errors also. In market leadership AI make competitive advantages. The operational efficiency of AI will be better positioned to adapt, innovate and thrive in an increasingly complex and dynamic business landscape.

C) Enhanced customer experience: The pace of technological innovation has significantly raised customer expectations. People today wanted effortless, personalized and calculative service. Artificial intelligence is reshaping the customer service landscape by enabling businesses to move from reactive proactive customer care. AI has ability predict customer needs, market demand, and routine checkup and deliver personalized service in quick time.

D) Faster innovation: AI has become increasingly popular over recent years as some of the best technologies can assist in revolutionizing organizations worldwide. AI can improve innovation by generating new ideas, evaluating new ideas, conducting analysis, improving the decision making process, providing faster proto typing, assessing risks and much more.

E) Cost reduction: AI based management systems optimize energy consumption by analyzing historical data such as weather patterns and building occupancy. This helps businesses to cut costs, enhance their operational efficiency and boost their overall sustainability.

F) Scalability: In sustainable growth and innovation AI scalability has emerged as a cornerstone. AI scalability refers to the ability of AI systems to adapt to increased workloads by enhancing their complexity, speed or size without compromising performance. This section deals into the mechanism that enable AI systems to scale efficiency, addressing the multifaceted approaches that under grid scalable AI solutions.

ARTIFICIAL INTELLIGENCE IN DIFFERENT SECTORS

Artificial Intelligence in Financial Services – AI has given the world of banking and finance in new ways to meet the customer demands of smarter, safer and more convenient ways to access, spend, save and invest money.

Example: **Gynger** uses AI to power its platform for financing tech purchases, offering solutions for both buyers and vendors. The company says creating an account is quick and easy for buyers who can get approved to start accessing flexible payment terms for hardware and software purchases by the next day.

ENOVA uses AI and machine learning in its lending platform to provide advanced financial analytics and credit assessment. AI can help to solve real life problems, like emergency costs and bank loans for small businesses.

Socure created ID platform, an identity verification system that uses machine learning and AI to analyze an applicant online, offline and social data, which helps clients meet strict KYC conditions.

Artificial Intelligence in Healthcare – In healthcare system AI simplifies the lives of patients, doctors and hospital management by performing typically tasks. Using AI technologies, doctor can then make quicker and more accurate diagnoses, health administrators can locate electronic health records faster and patients can receive more timely and personalized treatments.

Example: **Elise AI** specializes in conversational AI solutions. In the healthcare space, Elise AI offers powered technology that can automate administrative tasks like appointment scheduling and sending payment reminders.

Evidation's mobile app supports user health through rewards and education content. It also gives them the option of participating in health research for life science companies, government agencies and academic institutions.

Cohere Health uses AI and machine learning to revolutionize prior authorization processes to ensure patients can access care swiftly.

Artificial Intelligence in Retail – AI changes the retail sector in digital step. Year by year retail industry has going to a digital transformation. It has increased speed, efficiency and accuracy across every branch of retail business. It is forecasted that more than 85% of enterprises will be using AI by 2030.

Example: **Inventory Management** AI business intelligence tools forecast industry shifts and make proactive changes to a company's marketing, merchandising and business strategies. This also helps to improve supply chain planning.

Dynamic Outreach AI systems learn a consumer's behaviors and preference through repeated interactions to develop a detailed shopper profile and utilize this information to deliver proactive and personalized outbound marketing.

Visual Curtain Algorithmic engines translate real world browsing behaviors into digital retail opportunities by allowing customers to discover new or related products using image based search and analysis.

Artificial Intelligence in Transportation – In inventory and warehouse management AI has truly revolutionized in transportation. The use of AI in transportation is highly remarkable in short term or long term predictions.

Example: **Tesla** leverages AI to enable self-driving capabilities in its range of vehicles. This automotive giant uses AI potential to detect driver's behaviors such as level of fatigue and preventing the occurrence of feasible mishaps on the roads.

BMW uses 400+ AI applications across its operational processes. Some of the latest models of the brand are equipped with AI powered personal assistants, enhancing drivers convenience and safety by performing a multitude of tasks depending on drivers preferences and behavior.

Hitachi the industry leader is renowned for using AI in transportation. Leveraging the power of IoT and AI Hitachi analyzes vast troves of data, offering comprehensive fleet monitoring and ensuring the longevity of fleet assets.

Artificial Intelligence in Educations – In 2024, AI technologies are revolutionizing the academic landscape, offering unprecedented opportunities for personalized learning, administrative efficiency and improved educational outcomes. Educators and administrators can now leverage AI to analyze vast amounts of data, providing insights that drive informed decisions and strategies.

Example: **Adaptive Learning** AI driven platforms assess student's skill levels in real time and tailor institutional content to meet individual needs.

Data and Learning Analytics AI helps analyze data from online learning portals, classrooms attendance and grades.

Classroom Management platforms use AI to gamify classroom management. AI tracks student behavior and badges and providing teacher with insights into classroom dynamics to manage and motivate students.

Chatbots and Virtual Assistants AI driven chatbots such as Mainstay provide students with immediate support and assistance outside classroom hours.

Table: 1. Artificial Intelligence (AI) market size worldwide from 2020-2030 (in billion U.S. dollars)

YEAR	MARKET SIZE (IN BILLION U.S. DOLLARS)	% OF INCREASE / DECREASE
2020	93.27	-
2021	202.59	117.21
2022	124.79	(38.40)
2023	135.93	8.93
2024	184.04	35.39
2025 (expected)	243.72	32.43
2026 (expected)	320.14	31.35
2027 (expected)	415.61	29.82
2028 (expected)	529.23	27.34
2029 (expected)	667.74	26.17
2030 (expected)	826.73	23.81

Source: Statista 2024

Day by day the value of artificial intelligence is rising up tremendously. The whole world is depending on artificial intelligence in a great manner. From the above table it has been shown that the market size of AI has been increased by 117.21 percent in 2021 compared to the previous year 2020. Due to CORONA we mostly depend on technology that's why the AI market size has been increased. But in 2022 the market size was down by 38.40 percent compared to the previous year. From the year 2024 to 2030 it expect that the market size will increase by 35.39, 32.43, 31.35, 29.82, 27.34. 26.17 and 23.81 percent respectively.

Table: 2. Year wise distribution of startups recognized with at least 1 women director

YEAR	NO OF STARTUPS	% OF INCREASED / DECRESED
2017	1500 +	-
2018	5000 +	233.33
2019	10000+	100
2020	16000 +	60
2021	26000 +	62.5
2022	38000 +	46.15
2023	58000 +	34.48

Source: GOI, Ministry of Commerce and Industry, Department for Promotion of Industry and Internal Trade.

From the above table, it has been shows that year wise startups increased significantly. In the year 2016-17 the total number of startups was more than 1500. In the year 2017-18 the number has been increased by three times compared to the previous year, whereas in 2018-19 the number of startups has been increased by double compared to the previous year 2017-18. From the year 2019-20 to 2022-23 the number of startups has been increased by 60, 62.5, 46.15 and 34.48 percent respectively.

Region wise startups in different sectors:

Table: 3. NORTHERN REGION

SECTOR	PERCENTAGE
IT services	29%
Construction	14%
Professional and Commercial services	15%
Education	18%
Healthcare & Life science	24%

Source: GOI, Ministry of Commerce and Industry, Department for Promotion of Industry and Internal Trade.

In Northern Region the AI was mostly used in IT sector (29%). After IT sector AI was mostly used in healthcare sector (24%) followed by education sector (18%), Professional & Commercial sector (15%) and Construction sector (14%).

Table: 4. NORTH-EAST REGION:

SECTOR	PERCENTAGE
Construction	26%
Healthcare and Life science	18%
IT services	17%
Education	18%
Agriculture	21%

Source: GOI, Ministry of Commerce and Industry, Department for Promotion of Industry and Internal Trade.

In North-East Region the AI was mostly used in Construction sector (26%). After Construction sector AI was mostly used in Agriculture sector (21%) followed by Healthcare and Education sector (18% each) and 17% in IT services.

Table: 5. EAST REGION

SECTOR	PERCENTAGE
IT services	26%
Education	16%
Agriculture	16%
Construction	21%
Healthcare and Life science	21%

Source: GOI, Ministry of Commerce and Industry, Department for Promotion of Industry and Internal Trade

In Eastern Region the AI was mostly used in IT sector (26%). After IT sectors AI was mostly used in healthcare and Construction sector (21% each) followed by education and Agriculture sector (16% each).

Table: 6. CENTRAL REGION

SECTOR	PERCENTAGE
IT services	26%
Construction	16%
Education	16%
Healthcare and Life science	20%
Agriculture	22%

Source: GOI, Ministry of Commerce and Industry, Department for Promotion of Industry and Internal Trade.

In Central Region the AI was mostly used in IT sector (26%). After IT sectors AI was mostly used in Agriculture sector (22%) followed by healthcare sector (22%), Education (16%) and Construction sectors (16%).

Table: 7. SOUTHERN REGION

SECTOR	PERCENTAGE
IT services	36%
Food and Beverages	12%
Agriculture	13%
Education	16%
Healthcare and Life science	23%

Source: GOI, Ministry of Commerce and Industry, Department for Promotion of Industry and Internal Trade

In Southern Region the AI was mostly used in IT sector (36%). After IT sector AI was mostly used in healthcare sector (23%) followed by education sector (16%), Agriculture sector (13%) and Food and Beverages (12%).

Table: 8. WEST REGION:

SECTOR	PERCENTAGE
IT services	27%
Food and Beverages	15%
Professional and Commercial services	14%
Agriculture	16%
Healthcare and Life science	28%

Source: GOI, Ministry of Commerce and Industry, Department for Promotion of Industry and Internal Trade.

In Western Region the AI was mostly used in Healthcare sector (28%). After Healthcare sector AI was mostly used in IT sector (27%) followed by Agriculture sector (16%), Food and Beverages (15%) and Professional and Commercial sector (14%).

Table: 9. UNION TERITORIES :

SECTOR	PERCENTAGE
IT services	27%
Food and Beverages	15%
Professional and Commercial services	14%
Agriculture	16%
Healthcare and Life science	28%

Source: GOI, Ministry of Commerce and Industry, Department for Promotion of Industry and Internal Trade.

In Union Territories the AI was mostly used in Travel and Tourism sector (28%). After Travel and Tourism sector AI was mostly used in IT sector (24%) followed by Construction sector (21%), Non-Renewable Energy sector (15%) and Agriculture sector (12%).

CONCLUSION:

In digital world one technology that has taken the world by storm is artificial technology. From the chatbots to predictive analytics, AI has the power to automate tasks and provide valuable insights. Artificial intelligence is helping startups to be more efficient, make better decisions and stay ahead of the curve. In 2023, despite facing global economic and regulatory challenges, Indian startups have enhancing their business significantly. The country now has over 58000 women director led startups and cumulative funding over the last five years has exceeded $ 100 billion. In worldwide, artificial intelligence has market size over $ 135 billion. AI offers aspiring Indian entrepreneurs a good opportunity and create impactful, scalable businesses. Whether it's revolutionizing agriculture, education or healthcare, AI is the key to unlocking your startups full potential. In today's world artificial intelligence in startups is no longer optional, it is necessary for staying competitive.

♠ References :

1. Ganeshan, M.K. and et.al. (2023). Artificial Intelligence in Entrepreneurs and Startups through Human Resource Management in India. Journal of Propulsion Technology, 44(6), 5340-5345.
2. Govindarajan, M. (2019). Artificial Intelligence Startups in India. The Management Accountant Journal, https://doi.org/10.33516/maj.v54i12., 54(12), 44-47.
3. Mohanty, Soumendra. (2019). Study of Use of Artificial Intelligence as an Enabler for Startup Success. International Journal of Scientific Research & Engineering Trends, 5(6), 2265-2268.
4. Pati, Jyotirmayee, and et.al. (2024). Challenges and Opportunities of Implementing AI in Startups: An Indian Perspective. Library Progress International, 44(3).
5. Sreenivasan, Aswathy. and Suresh, M. (2022). Adoption of Artificial Intelligence (AI) in Startups. IEOM Society, 248-259.
6. Yaranal, Kirankumar. and LN, Arvind. (2023) The Indian Artificial Intelligent Startups: An Overview. International Journal of Research Publication and Reviews, 4(10), 1336-1341.

♠ Websites :

1. https://www.datacamp.com/blog/ai-in-decision-making
2. https://www.zartis.com/ai-for-operational-efficiency-use-cases-and-examples/#:~:text=By%20automating%20routine%20tasks%2C%20predicting,Cost%20savings%20and%20reduced%20errors
3. https://www.forbes.com/sites/tonybradley/2024/10/11/how-ai-is-revolutionizing-customer-experience/
4. https://www.google.com/amp/s/www.hypeinnovation.com/blog/how-ai-is-accelerating-innovation%3fhs_amp=true
5. https://exadel.com/news/reduce-costs-in-businesses-with-ai/

6. https://deepgram.com/ai-glossary/ai-scalability
7. https://yourstory.com/2024/04/ai-artificial-intelligence-impact-indian-startup-ecosystem-finance-education-retail-startups
8. https://builtin.com/artificial-intelligence/artificial-intelligence-healthcare
9. https://global.hitachi-solutions.com/blog/ai-in-retail/
10. https://appinventiv.com/blog/ai-in-transportation/#:~:text=AI%2Dpowered%20vehicle%20tracking%20systems,efficiency%2C%20and%20schedule%20maintenance%20proactively.
11. https://onlinedegrees.sandiego.edu/artificial-intelligence-education/#:~:text=AI%20is%20used%20in%20education,tools%20make%20learning%20more%20engaging.
12. https://www.google.com/amp/s/m.economictimes.com/tech/technology/70-of-indian-startups-bet-big-on-ai-to-fuel-growth-report/amp_articleshow/106551884.cms
13. https://grow.google/intl/en_in/startups/ai-business-startup-ideas-india/
14. https://grow.google/intl/en_in/startups/ai-skillsets-career-paths-india/

Role of AI in Criminal Jurisprudence

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ABSTRACT

Artificial Intelligence (AI) is fundamentally transforming criminal jurisprudence by modernizing traditional approaches to investigation, evidence evaluation, and judicial decision-making. This chapter delves into the diverse applications of AI within contemporary criminal justice systems, focusing on areas such as predictive policing, forensic advancements, legal research, and court processes. Despite its promise of improved accuracy and efficiency, AI also presents challenges, including ethical concerns, algorithmic biases, and risks to individual rights. The chapter emphasizes the necessity of regulatory standards and human oversight to address these issues and ensure the ethical deployment of AI in legal frameworks. Through an analysis of global case studies and emerging trends, this work highlights the transformative potential of AI and its impact on the future of criminal law and justice.

Keywords: *Artificial Intelligence, criminal jurisprudence, predictive policing, ethical challenges, algorithmic fairness*

INTRODUCTION

The integration of Artificial Intelligence (AI) into criminal jurisprudence represents a paradigm shift in how justice is administered. From aiding in investigations to adjudicating cases, AI has become an indispensable tool. This chapter examines the technological advancements in AI and their applications in criminal law while addressing ethical, legal, and social implications.

The legal system, traditionally reliant on human expertise and judgment, now benefits from AI's ability to process vast amounts of data rapidly and provide insights that were previously unattainable. However, the integration of AI in criminal jurisprudence necessitates a balanced approach to ensure that technological advancements align with human values and the principles of justice.

PREDICTIVE POLICING AND CRIME PREVENTION

Predictive policing uses AI algorithms to analyze historical crime data and predict potential criminal activity (Perry et al., 2013). By identifying high-risk areas and times for crime occurrence, these systems help law enforcement agencies allocate resources more effectively.

Benefits:

1. Resource Optimization: Predictive tools like PredPol improve the efficiency of law enforcement agencies by directing patrols to areas with a high likelihood of criminal activity.
2. Proactive Measures: The identification of patterns allows for proactive interventions, potentially preventing crimes before they occur.

Challenges:

1. Data Bias: As Richardson et al. (2019) and Lum and Isaac (2016) highlight, biased historical data can perpetuate systemic inequalities, leading to over-policing in minority communities.
2. Ethical Concerns: The use of predictive algorithms raises questions about privacy rights and the potential for racial profiling.

Addressing these issues requires transparent algorithm design, diverse data sets, and continuous auditing to minimize bias and ensure fairness.

AI IN FORENSIC ANALYSIS

AI is transforming forensic science by automating tasks such as DNA analysis, fingerprint matching, and facial recognition. Machine learning algorithms enhance the accuracy and speed of these processes, providing invaluable support in criminal investigations.

Advancements:

1. DNA Analysis: AI tools expedite the processing of DNA evidence, reducing backlog and increasing the likelihood of solving cases.
2. Facial Recognition: Modern systems, trained on vast image databases, can identify suspects with remarkable precision.
3. Pattern Recognition: AI excels in matching fingerprints, bullet trajectories, and other forensic evidence to uncover critical links in investigations.

Limitations:

1. Reliability Issues: Errors in facial recognition have led to wrongful arrests, as documented by Garvie et al. (2016).
2. Cognitive Bias: Nakhaeizadeh et al. (2014) discuss the risk of human analysts being influenced by AI-generated results, which can affect objectivity.

Ensuring the reliability of AI-driven forensic tools involves rigorous testing, cross-validation with human expertise, and adherence to international standards for forensic science.

LEGAL RESEARCH AND CASE MANAGEMENT

AI-powered platforms like ROSS Intelligence and LexisNexis streamline legal research by quickly analyzing vast databases of case law and legal literature. These tools save time and enhance accuracy in identifying relevant precedents.

Impact:

1. Efficiency: Legal professionals can process complex queries in minutes, allowing for more informed decision-making.
2. Cost Reduction: Automated research tools lower operational costs for law firms and judiciary systems.

Concerns:

1. Over-Reliance: Excessive dependence on AI may erode critical thinking skills among lawyers (Susskind, 2020).
2. Data Integrity: The effectiveness of these tools hinges on the quality and comprehensiveness of the databases they access.

Balancing AI's efficiency with the preservation of traditional legal skills is crucial to maintaining the integrity of the profession.

JUDICIAL DECISION-MAKING

AI tools are increasingly being used to assist judges in decision-making processes, such as bail assessments and sentencing recommendations. For instance, the COMPAS algorithm predicts recidivism risk but has been criticized for racial bias (Angwin et al., 2016).

Applications:
1. Risk Assessment: AI systems analyze factors like prior convictions and socioeconomic background to estimate recidivism probabilities.
2. Sentencing Recommendations: Algorithms suggest sentencing ranges based on legal guidelines and case precedents.

Controversies:
1. Transparency: Lack of explainability in AI models leads to skepticism about their fairness.
2. Bias: Dressel and Farid (2018) demonstrated that algorithms like COMPAS exhibit significant racial disparities.

Ensuring transparency and accountability in AI-assisted judicial processes involves developing explainable AI (XAI) models and incorporating judicial oversight to validate recommendations.

ETHICAL AND LEGAL CHALLENGES

The use of AI in criminal jurisprudence raises significant ethical concerns. Algorithmic bias, lack of transparency, and potential violations of privacy are key issues (Barocas & Selbst, 2016).

Ethical Concerns:
1. Algorithmic Bias: Disparities in AI outcomes often stem from biased training data, disproportionately affecting marginalized groups.
2. Accountability: Determining liability for errors made by AI systems remains unresolved.

Legal Considerations:
1. Privacy: The collection and analysis of personal data by AI tools can infringe on individual rights.
2. Regulation: The absence of standardized guidelines complicates the adoption of AI in legal systems.

Robust ethical guidelines and international cooperation are essential to address these challenges and ensure responsible AI use.

REGULATORY FRAMEWORKS AND GOVERNANCE

To address the challenges associated with AI in criminal jurisprudence, robust regulatory frameworks are necessary. International efforts, such as the European Union's AI Act, aim to establish guidelines for ethical AI use (European Commission, 2021).

Recommendations:
1. Standards: Develop globally recognized standards for AI design and deployment.
2. Oversight: Establish independent regulatory bodies to monitor AI applications in criminal justice.
3. Training: Equip legal professionals with the knowledge to understand and critique AI systems.

CASE STUDIES

This section examines notable case studies to illustrate the practical applications and challenges of AI in criminal jurisprudence.

China:

China's judicial system employs AI tools like the "Smart Court" to streamline case processing. While efficiency has improved, concerns about surveillance and civil liberties persist.

United States:

The implementation of facial recognition technology in policing has sparked debates about accuracy and ethical use, with several high-profile cases highlighting errors and biases.

FUTURE DIRECTIONS

The future of AI in criminal jurisprudence lies in developing unbiased algorithms, enhancing human-AI collaboration, and fostering public trust. Research into explainable AI (XAI) and ongoing dialogue among stakeholders will be essential to achieving these goals (Gunning et al., 2019).

Goals:

1. Unbiased Systems: Invest in research to minimize algorithmic bias.
2. Human-AI Collaboration: Ensure that AI supplements rather than replaces human judgment.
3. Public Engagement: Build trust through transparency and education.

CONCLUSION

AI holds immense potential to transform criminal jurisprudence, offering innovative solutions to longstanding challenges. However, its adoption must be guided by ethical principles, legal safeguards, and a commitment to justice. By balancing technological advancement with human values, AI can contribute to a more equitable and efficient legal system.

From Physical to Digital: Exploring Tokenisation of Real-World Assets

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INTRODUCTION

In the digital world, *inter alia*, the concept of ownership is evolving to keep pace with technological advancements. It no longer signifies what traditional jurists have described so far. Today, a person sitting in the USA can invest in real estate in Sri Lanka without physically viewing the property or purchasing it in full. A 2 BHK apartment in Delhi can have multiple investors, and the owner can access funds without resorting to traditional methods such as selling the apartment or mortgaging it with a bank. This can be achieved through the process of tokenizing real-world assets.

The concept of tokenisation is relatively new. The world witnessed the rise of non-fungible tokens (NFTs), with an artist selling a piece of artwork for over $69 million. This demonstrates that ownership can transcend the boundaries of traditional legal concepts, allowing individuals to invest in high-value assets without having to spend significant capital.

Tokenisation of real-world assets extends beyond art. It can encompass real estate, stocks, intellectual property, and even money, enabling fractional ownership, which democratizes investments. As a result, individuals from low-income groups can now invest in high-value properties without being restricted by geographical boundaries.

Despite these benefits, the process of tokenizing real-world assets has yet to gain widespread traction in India and remains in its early stages. A pilot project is currently underway in Gujarat's GIFT City. This paper aims to explore the meaning of tokenisation, examine the current legal framework in India related to tokenization, and propose future steps to streamline the process.

SIGNIFICANCE OF TOKENISATION IN DEMOCRATIZING INVESTMENTS

The process of tokenisation of real-world assets plays a transformative role in making investments democratic. The real-world assets are limited. These assets can be held by one specific group of individuals. But the process of tokenisation has opened the spectrum of investment in real-world assets to a broader range of investors. Since tokenisation divides the high value real world assets into small digital tokens, these can be purchased by more individuals. This enables investors with smaller capital to invest without having to take much financial burden.

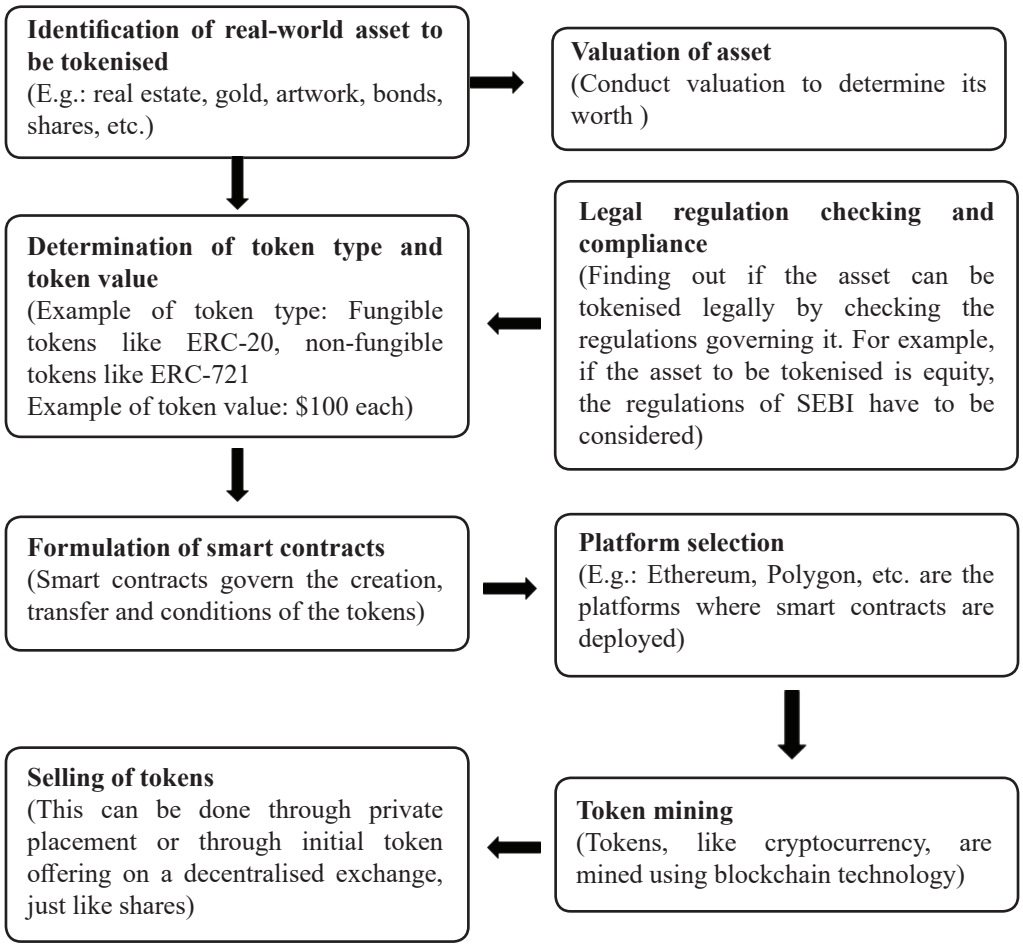
Since tokenisation of assets take place digitally through the process of blockchain, the geographical limit in investing is also removed. Now a person from any place can buy digital units of a real-world assets that is located at a far-off place. This system has also done away with the intermediaries and brokers in real world assets, who tend to increase the price of the asset manifold.

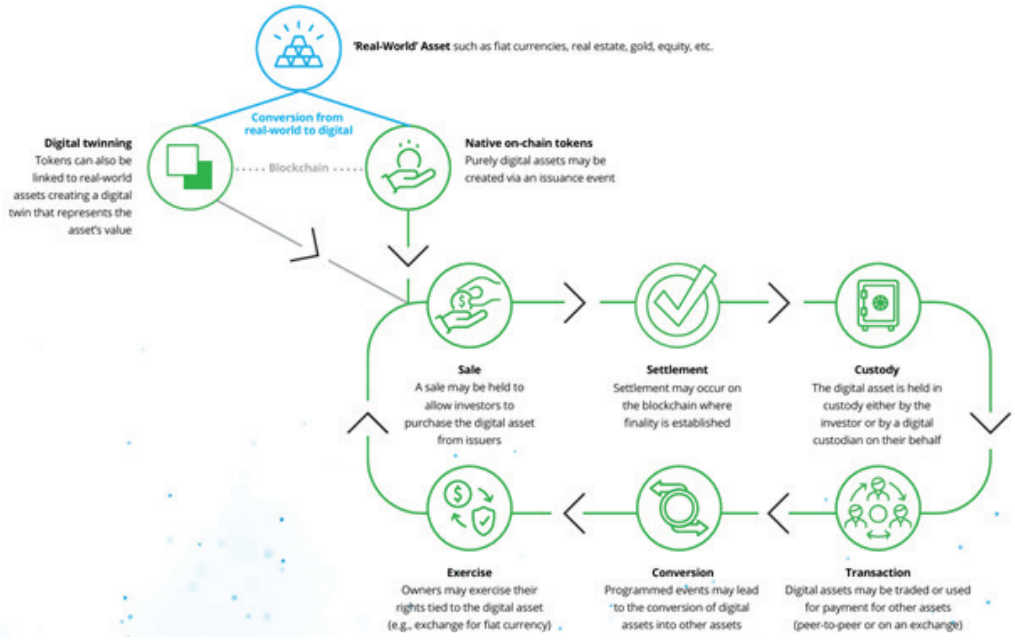
The tokenised assets can be traded at anytime from any place which makes it very convenient for a person with fixed working hours to invest. For instance, a person employed in a company cannot go out on a working day during the working hours to search for a flat he wants to invest in. He has to either wait for a day off or for the non-working hours of the day. But in case of a tokenised asset, the person can trade at any hours of the day, as per his convenience.

The real-world assets such as real estate or gold are relatively illiquid. That means, one cannot derive money from these assets whenever he wants to. But with tokenisation of these assets, the process has become very easy and quick. The tokens can be traded swiftly without much hassle.

UNDERSTANDING TOKENISATION

The tokenisation of real-world assets involves the conversion of these assets into digital token using the blockchain technology. Each token represents ownership of the real-world asset. The price of the token goes up and down on the basis of the price of the underlying asset. The question is how a real-world asset is tokenised and sold? The process has been given below:





Source: Deloitte

CRYPTOCURRENCIES VERSUS TOKENISED ASSETS

The main difference between cryptocurrency and tokenised assets lies in their purpose. They also differ in the way they function. Although both use blockchain technology, they are fundamentally different. Cryptocurrencies are digital currencies designed to function as a medium of exchange, similar to money. Examples of cryptocurrencies include Bitcoin, Ethereum, and Ripple. Cryptocurrencies are native to their respective blockchains; for instance, Bitcoin is native to the Bitcoin blockchain.

On the other hand, tokenised assets represent ownership in the digitized form of real-world assets. Tokenisation is done using blockchain technology, and the tokens are based on assets that exist in the real world. The value of a token depends on the asset it is linked to, making it a way to make an otherwise illiquid asset liquid. In contrast, cryptocurrencies do not represent ownership. Their value is determined by market demand. Like physical currency, cryptocurrencies are also limited in supply---- the greater the demand, the higher their value. The value of a tokenised asset depends on the underlying asset. For example, if 1 kg of gold is tokenized, the value of the token will increase if the price of gold rises, and vice versa.

TYPES OF TOKENISATION

The tokenisation of real-world assets can take various forms, depending on the type of underlying asset being tokenised. Some of these types are outlined below:

1. **Asset-Backed Tokenisation:** These tokens always have an underlying real-world asset. These assets can include:
   - Real estate, such as land, buildings, etc.
   - Commodities, such as gold, oil, etc.
   - Intellectual property, such as patents, trademarks, etc. This can also include royalties from books, music, movies, etc.

2. **Utility Tokenisation:** These tokens are used in technology and service industries. An example of a utility token is one that grants discounts on an e-commerce application or a token that provides voting rights to the token-holder.
3. **Security Tokenisation:** These tokens represent ownership of a financial asset, such as shares in a company. Security token holders have rights to dividends or interest, depending on the security. The tokenisation of these assets is governed by securities regulatory authorities, such as the Securities and Exchange Board of India (SEBI).
4. **Non-Fungible Tokens (NFTs):** These are unique tokens representing one-of-a-kind assets, such as a unique piece of art or collectibles. These tokens are not interchangeable with other tokens.
5. **Environmental Tokens:** These tokens are linked to carbon credits, sustainability projects, and other initiatives aimed at improving the environment.

ADVANTAGES OF TOKENISATION

- **Liquidity for traditionally illiquid assets:** Traditionally illiquid assets such as real estate, gold, etc., are not very useful when liquid money is required. If these assets are tokenised, the token-holder can convert them into money whenever needed just by selling them to someone else. This requires very little time and effort, making it highly appropriate for those who prefer to keep assets liquid.
  Moreover, the owner of the real-world asset can generate money from the asset without parting with it. They will not have to sell, lease, or mortgage the asset and will continue to enjoy ownership. They will only issue some tokens to interested investors and receive the money.
- **Fractional ownership and democratisation of investments:** Investing in tokenised assets requires a very small amount of capital since ownership is fractional. For instance, land worth ₹1 crore is generally unaffordable for many, despite their interest in investing. In such a situation, they can invest in the tokenised form of that particular land. Suppose the landowner issues 10,000 tokens at ₹1,000 each—a small investor who either does not want to or cannot afford to invest much can still invest in just one token. This has democratised investments, allowing even small investors to invest while staying well within their financial limits.
- **Enhanced transparency and security via blockchain:** The tokenisation of real-world assets uses blockchain technology. Like cryptocurrencies, tokens are mined by miners. On the blockchain, a decentralised ledger is always maintained, and all peers have access to it. Once a new crypto asset or token is mined, it is added to the ledger. All trading activities on the blockchain are recorded in the ledger. Altering or manipulating the ledger is practically impossible, and if a change needs to be made, it must be approved by all peers on the blockchain. This makes the entire process highly transparent and secure.
- **Reduced transaction costs and geographical barriers:** Since the entire process of tokenisation and the trading of real-world assets is decentralised, there are technically no geographical barriers. The absence of such barriers makes the process cost-effective and accessible from any corner of the world. The only requirement is a stable internet connection.

CHALLENGES IN TOKENISATION

Despite its many advantages, the process of tokenisation is still in its nascent stage and faces numerous challenges in full implementation. Some of these challenges are listed below:

- **Regulatory uncertainties and legal hurdles:** There is still no clear regulation on the tokenisation of real-world assets. If real estate is tokenised, the Real Estate Regulatory Authority of each state must oversee it. Similarly, if a security is tokenised, it requires governance by the Securities and Exchange Board of India (SEBI). However, since tokenisation transcends geographical boundaries, determining the jurisdiction of a particular regulatory authority is difficult. In India, there is currently no regulation on tokenisation, and it remains uncertain when such a regulation will be introduced.

- **Technological limitations and interoperability issues:** The tokenisation of real-world assets is executed through smart contracts, which are created digitally. These digital contracts may have bugs, coding errors, or other technical vulnerabilities, making them susceptible to hacking. This could compromise user security and lead to financial losses, raising significant data privacy concerns.
- **Issues with legal ownership:** Tokenised assets represent real-world assets, but proving this ownership before a traditional court of law can be challenging. Moreover, considering the Indian population specifically, a majority may not fully understand the technicalities of tokenised assets. This lack of awareness could lead to mismanagement of tokens, with unclear legal remedies available in such situations.
- **High initial setup costs:** Establishing the technical and legal infrastructure required to facilitate the trading of tokenised assets involves high initial costs.
- **Taxation and accounting challenges:** Many countries do not have specific tax regulations for tokenised assets. For example, in India, it is uncertain whether profits earned from trading tokenised assets would fall under the category of "Income from Capital Gains."

TOKENISATION IN INDIA: THE CURRENT LANDSCAPE

- **Emerging Initiatives: GIFT City Pilot Project**
  Gujarat International Finance Tec-City (GIFT City) is at the forefront of India's asset tokenization efforts. As the country's first International Financial Services Centre (IFSC), GIFT City is preparing to launch a regulated platform for tokenizing real-world assets (RWAs). The initial focus will be on real estate, with plans to expand into assets like art, aircraft, and ships. This initiative aims to attract foreign investors by providing fractional ownership opportunities and enhancing liquidity in traditionally illiquid markets.
- **Legal and Regulatory Framework in India**
  India's regulatory environment for asset tokenization is still developing. Currently, there is no dedicated legislation or regulator overseeing real estate tokenization. However, regulatory bodies such as the International Financial Services Centres Authority (IFSCA), the Reserve Bank of India (RBI), and the Securities and Exchange Board of India (SEBI) are exploring frameworks to facilitate and govern tokenization activities. The IFSCA, headquartered in GIFT City, is focused on establishing guidelines that prioritize market integrity, financial stability, and consumer protection.
  consumer protection.
- **Comparison with Global Practices**
  Globally, asset tokenization is witnessing varied regulatory approaches:
  - **United States:** The U.S. has implemented comprehensive regulations for asset tokenization, with the Securities and Exchange Commission (SEC) providing clear guidelines for security tokens.
  - **European Union:** The EU is developing the Markets in Crypto-Assets (MiCA) framework to regulate digital assets, including tokenized securities.
  - **Singapore and Dubai:** Both have established themselves as crypto-friendly hubs, offering clear regulatory frameworks that encourage innovation in asset tokenization.

India's approach is more cautious, focusing on creating a balanced framework that fosters innovation while ensuring investor protection and market stability. The initiatives in GIFT City reflect a strategic move to position India competitively in the global financial landscape.

CONCLUSION

Tokenisation of real-world assets represents a transformative shift in the investment landscape, breaking down traditional barriers to ownership and providing opportunities for individuals across the globe to participate in high-value markets. The fractional ownership model made possible through tokenisation

opens doors for a wider demographic, democratizing investments that were once confined to the wealthy. Moreover, blockchain technology ensures enhanced transparency, security, and liquidity, offering a streamlined and efficient alternative to conventional investment mechanisms.

However, despite its potential, tokenisation faces significant challenges in its widespread adoption. Regulatory uncertainties, technological limitations, and issues surrounding legal ownership and taxation need to be addressed to foster a conducive environment for its growth. India, with its burgeoning fintech ecosystem, is on the cusp of embracing this innovative approach, as demonstrated by initiatives like the GIFT City pilot project. While global counterparts like the United States and Singapore have made strides in implementing clear regulatory frameworks, India's cautious approach, focusing on market integrity and investor protection, will be crucial in shaping its regulatory landscape.

The future of tokenisation in India looks promising, with the potential to position the country as a competitive player in the global financial market. By addressing the legal, regulatory, and technological challenges head-on, India can unlock the full potential of tokenisation, offering individuals and businesses alike the opportunity to leverage a digitalized, borderless, and more liquid investment ecosystem.

References:

1. Deloitte Blockchain & Digital Assets, Deloitte US. (2024). *Tokenization: Realizing the vision of a future financial ecosystem.* https://www2.deloitte.com/content/dam/Deloitte/us/Documents/financial-services/us-bda-steering-tokenized-assets-pov.pdf
2. Kumar, S. (2024). *UNLOCKING THE FUTURE: UNDERSTANDING TOKENIZATION OF REAL-WORLD ASSETS AND ITS LEGAL IMPLICATIONS* [Report]. https://www.wilkauslander.com/R504FS355/assets/files/News/2024_05_23_Unlocking_the_future_Understanding_Tokenization_of_Real_World_Assets_and_Its_Legal_Implications.pdf
3. Hentov, E., Gorshkov, V., & State Street Global Advisors. (2024). *Asset tokenization in Capital Markets: A primer.* https://www.ssga.com/library-content/assets/pdf/global/digital-assets/2024/asset-tokenization-in-capital-markets.pdf?utm_source=chatgpt.com

AI-Driven E-Pharmacy Adoption: Analysing the Impact of Age and Socio-Economic Factors on Patient Behaviour

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ABSTRACT

The integration of artificial intelligence (AI) in healthcare has transformed service delivery, including the adoption of e-pharmacy platforms for convenient medication access. This study examines socio-economic factors influencing e-pharmacy acceptance, focusing on age groups and annual family income. A survey of 242 respondents was analyzed using Levene's Statistic, one-way ANOVA, and Welch's Statistic to address variances. Results show the highest acceptance among respondents under 28 years and the lowest among those aged 28–43 years. Acceptance was also higher among individuals earning less than 10 lakhs annually compared to those earning more. While ANOVA results indicated significant differences based on age, Welch's Statistic confirmed significant effects for both age and income, accounting for variance violations. Younger individuals and those with lower incomes are more likely to adopt e-pharmacy services, highlighting its accessibility. However, challenges such as privacy concerns, credibility issues, and inefficiencies remain barriers to widespread adoption. Despite these challenges, AI-driven e-pharmacy systems show potential, particularly for older adults managing chronic conditions. Addressing safety, transparency, and legal concerns is crucial to building trust in these services. Future research should explore the role of digital literacy and education in shaping e-pharmacy adoption behaviors.

Keywords : *E-pharmacy, Artificial Intelligence, Healthcare Technology, Socio-economic Factors, Age Groups, Annual Family Income*

INTRODUCTION

Artificial intelligence (AI) has numerous applications in healthcare, such as claims processing, clinical documentation, revenue cycle management, medical records management, and e-pharmacy (Commins, 2010). The shift from traditional to internet-based healthcare services has empowered consumers to better understand health conditions and take a more proactive approach toward managing their health (Rains, 2007). E-pharmacy, or online pharmacy, involves the sale and direct delivery of medications through online platforms (Karahoca et al., 2018). Several remote communication methods have been explored, including electronic medical devices (Boeni et al., 2015; Arian et al., 2020; Ahmad et al., 2020), mobile applications (Brath et al., 2013; Criner et al., 2021), web applications (Vilasi et al., 2020; Graetz et al., 2018), text messages (Kassavou et al., 2020; Foreman et al., 2012; Huang et al., 2017), postal mail (Borah et al., 2016), phone calls (Ownby et al., 2012; Elliott et al., 2008; Kobb et al., 2003), e-prescriptions (Toscos et al., 2020; Bastani et al., 2021), and remote dispensing (Guadamuz et al., 2021). However, healthcare is a complex, safety-critical field, where technological failures can result in direct harm to patients (Patel et al., 2015). The study "Perception and Knowledge of Online Pharmacy Services among Consumers in Riyadh, Saudi Arabia: A Pilot Survey" by Alfahad et al. (2015) was used as a tool (questionnaire) to assess the acceptance of e-pharmacy services among consumers (patients) from various age groups and socio-economic backgrounds.

REVIEW OF LITERATURE

Studies indicate that smart technologies are set to transform future workplaces (Harokava et al., 2017). While there is a growing focus on AI for sustainability, attention should also shift to addressing the long-term sustainability of AI development and usage (Van Wynsberghe, 2021). A significant number of medical journals have published research utilizing machine learning technology to analyze vast health data sets for diagnosing and treating patients (Jiang et al., 2017). Globally, healthcare systems are grappling with challenges such as the increasing burden of illness, multimorbidity, disability due to aging, and epidemiological changes, along with growing demand for health services, rising societal expectations, and escalating healthcare costs (Atun, 2015). Through online purchasing platforms, consumers can better manage their healthcare needs and improve their families' well-being (Harbour et al., 2007; Song, 2007). Interestingly, two studies on patients with chronic diseases found that older adults had a higher medication adherence rate than younger adults (Criner et al., 2021; Huang et al., 2017). Additionally, one study showed that providing healthcare via text, video, or phone calls to older people in rural clinics could improve medication adherence (Kobb et al., 2003). Research also suggests that individuals with higher incomes are more likely to adopt e-pharmacy services compared to those with lower incomes (Sampene et al., 2024). Further studies have supported the idea that online shoppers with higher incomes value convenience and time-saving features, making online shopping more attractive (Pung, 2012). The positive relationship between income levels and online pharmacy purchases was also supported by Urbanavičiūtė (2022).

OBJECTIVE

To analyse the effect of patients of different age groups on the acceptance of E-Pharmacy application.
To explore the effect of demographic difference of patients' annual family income on the adoption of E-Pharmacy.

HYPOTHESIS

- H0 Acceptance of E-Pharmacy is significantly dependent upon age group.
- HA Acceptance of E-Pharmacy is not significantly dependent upon age group.
- H0 Acceptance of E-Pharmacy is significantly dependent upon Annual family income
- HA Acceptance of E-Pharmacy is not significantly dependent upon Annual family income

RESEARCH METHODOLOGY

This study employs a quantitative research design to analyze the acceptance of e-pharmacy services among 242 respondents based on age groups and annual family income. Data were collected through a structured survey and analyzed using statistical methods, including Levene's Statistic, one-way ANOVA, and Welch's Statistic. The age groups were categorized into four segments (less than 28 years, 28–43 years, 44–59 years, and more than 60 years), while annual family income was divided into three brackets (less than 5 lakhs, 5–10 lakhs, and more than 10 lakhs). These statistical tests assessed the homogeneity of variances and the significance of differences between groups, providing insights into the factors influencing e-pharmacy adoption.

ANALYSIS

This research study is conducted with the aim of finding the acceptance of telemedicine among 242 (N) respondents with regards to two socio economic factors namely age group and annual family income, using Levene Statistic, one way ANOVA methodology and Welch Statistic.

Age group score	N	Mean	Std. Deviation	Std. Error
Less than 28 years	128	5.1247	0.78692	0.06955
28-43 years	40	4.6187	0.49152	0.07772
44-59 years	52	4.6748	0.45324	0.06285
More than 60 years	22	4.6901	0.29278	0.06242
Total	242	4.9049	0.68648	0.04413
Annual Family Income Score				
Less than 5 Lakhs	160	4.9142	0.74545	0.05893
5-10 Lakhs	72	4.9217	0.58515	0.06896
More than 10 Lakhs	10	4.6346	0.12587	0.03980
Total	242	4.9049	0.68648	0.04413

The analysis began by categorizing the population into four age groups: under 28 years, 28-43 years, 44-59 years, and over 60 years. Additionally, annual family income was divided into three categories: less than 5 lakhs, 5-10 lakhs, and more than 10 lakhs. The scores were calculated as the averages for both age groups and income categories.

From the data, respondents under 28 years had the highest average score of 5.12 (SD=0.78), followed by those over 60 years with a mean of 4.69 (SD=0.29), 44-59 years with a mean of 4.67 (SD=0.45), and 28-43 years with a mean of 4.61 (SD=0.49). Regarding annual family income, those earning less than 5 lakhs had an average score of 4.91 (SD=0.74), while those earning more than 10 lakhs scored 4.63 (SD=0.12), and those earning between 5 and 10 lakhs had an average score of 4.92 (SD=0.58).

While the groups show numerical differences, it is important to determine if these differences are statistically significant. To assess this, a one-way ANOVA was conducted. Prior to running the ANOVA, Levene's test was used to check the homogeneity of the groups.

Test of Homogeneity of Variances

Age Group Score			
Levene Statistics	df1	df2	Sig.
13.141	3	238	<.001
Family Annual Income Score			
6.783	2	239	0.001

From the above table it can be concluded that the groups are not homogenous as the P value of Levene Statistics of Age group is 0.000 and the Annual income group is 0.001, all the P values are lower than .05(95% confidence). So, we can say homogeneity of variances is violated, which also means groups are not homogenous.

ANOVA
Age Group Score

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	13.230	3	4.410	10.460	<.001
Within Groups	100.343	238	0.422		
Total	113.573	241			

Annual Family Income Group

Between Groups	0.765	2	0.382	0.810	0.446
Within Groups	112.808	239	0.472		
Total	113.573	241			

So the above table shows that age Groups are numerically and statistically different from each other as the P value is lower than .05 and in case of Annual income group the difference is not statistically or significantly different from each other as the P value is 0.446 which is higher than 0.05. But since the groups are not homogenous, so we cannot rely on the one way ANOVA. We need to run a test which can manage the violation of homogeneity. In this regard we have conducted Welch statistics. The below table is showing the result of Welch statistics.

Welch	Statistics	df1	df2	Sig.
Age Group Score	11.076	3	90.184	<.001
Annual Family Income Score	11.039	2	77.429	<.001

The welch is showing significant result, so we can conclude that groups are statistically and significantly different from each other, hence we can accept our two of our null hypotheses, which are acceptance of E-Pharmacy is significantly dependent upon age group and acceptance of E-Pharmacy is significantly dependent upon annual family income.

Discussion

The benefits of artificial intelligence (AI) in healthcare have been widely discussed in medical literature (Dilsizian et al., 2014; Patel et al., 2009; Jha et al., 2016). However, the impact of digital technology on healthcare systems remains unclear (Jones et al., 2012). Deep learning technologies have been extensively used to set new standards in industries with abundant high-quality digital data, particularly where there is a strong economic incentive to automate tasks (LeCun et al., 2015). Recent studies show that AI-based healthcare applications can potentially match or even surpass the performance of clinicians in specific areas (De Fauw et al., 2018). Research indicates that individuals in the 40-50 age range are more likely to adopt e-pharmacy services, suggesting that age plays a significant role in e-pharmacy adoption (Ahalawat et al., 2024). Nonadherence to medications is a common issue among older adults, with a study showing that less than 50% of individuals over 60 follow prescribed medication regimens (Shruthi et al., 2016). Older adults are more likely to suffer from chronic conditions and take multiple medications daily (polypharmacy), which increases the need for quick and easy access to medicines, a need that e-pharmacy helps address (Bastani et al., 2021). My research also highlights that annual income significantly affects e-pharmacy adoption, as confirmed by Sampene et al. (2024). Mehzabin and Moniruzzaman (2019) found that individuals with higher incomes are more frequent online shoppers. Conversely, some studies suggest that factors like age and education may not significantly influence e-pharmacy purchasing behaviors (Fittler et al., 2013). Despite these advancements, AI-based healthcare technologies are still far from being fully integrated into clinical practice due to their differences from traditional methods (Lancet, 2017; Kelly et al., 2019). Furthermore, the sensitive personal data required for AI in healthcare raises concerns about privacy and potential legal challenges (Azencott, 2018; Mooney et al., 2018; Kayaalp, 2018). Transparency in AI system design is critical to ensuring safety in healthcare applications (Picardi et al., 2019). Additionally, AI applications have faced challenges like inefficiency and low productivity (Kocher et al., 2011). Issues around the credibility of online health information and concerns about the expertise of its providers have also been raised (Dutta Bergman, 2003; Lemire et al., 2008). Moreover, consumers have expressed hesitation in using online health services due to fears about the misuse of their personal data (Bansal et al., 2010; Beldad et al., 2010).

CONCLUSION

This study provides a comprehensive analysis of the factors influencing the acceptance of e-pharmacy services, with a specific focus on age groups and annual family income. The findings highlight that younger individuals (less than 28 years) exhibit the highest acceptance levels, emphasizing their comfort with digital platforms. Conversely, older adults also show moderate acceptance, particularly due to the convenience of accessing medications for chronic conditions. In terms of income, respondents with lower annual family

incomes (less than 5 lakhs) demonstrate greater adoption of e-pharmacy services, reflecting its potential to bridge accessibility gaps in healthcare. The statistical analyses, including Levene's Statistic, ANOVA, and Welch's Statistic, confirm the significant influence of both age and income on e-pharmacy adoption. However, the study also underscores critical challenges, such as privacy concerns, perceived lack of credibility, and inefficiencies in online health services. Addressing these issues is imperative for enhancing trust and fostering wider acceptance of e-pharmacy solutions. In conclusion, e-pharmacy services have emerged as a transformative tool in healthcare, leveraging AI to improve accessibility and convenience. However, their success relies on addressing barriers related to safety, transparency, and user confidence. Policymakers and healthcare providers must work collaboratively to create secure, reliable, and user-friendly e-pharmacy systems, ensuring equitable access for diverse demographic groups. Future research could delve into the role of digital literacy, education, and cultural factors in shaping e-pharmacy adoption, further enriching the understanding of this rapidly evolving domain.

♠ Reference :

1. Ahalawat, K., Tiwari, R., Johri, A., Wasiq, M., & Sharma, A. (2024). Determinants influencing the adoption behavior of Indian consumers in reference to online pharmacy purchases. *Cogent Business & Management,* 11(1), 2436136.
2. Ahmad, A., Chiu, V., & Arain, M. A. (2020). Users' perceptions of an in-home electronic medication dispensing system: a qualitative study. *Medical devices: Evidence and research*, 31-39.
3. Alfahad, N. F., Albelali, M. T., Khurshid, F., Al-Arifi, M. N., Al-Dhawailie, A. A., & Alsultan, M. S. (2015). Perception and knowledge to online pharmacy services among consumers in Riyadh, Saudi Arabia: a pilot survey. *Lat Am J Pharm,* 34(6), 1113-1118.
4. Arain, M. A., Ahmad, A., Chiu, V., & Kembel, L. (2021). Medication adherence support of an in-home electronic medication dispensing system for individuals living with chronic conditions: a pilot randomized controlled trial. *BMC geriatrics,* 21, 1-16.
5. Atun, R. (2015). Transitioning health systems for multimorbidity. *The Lancet*, 386(9995), 721-722.
6. Azencott, C. A. (2018). Machine learning and genomics: precision medicine versus patient privacy. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences,* 376(2128), 20170350.
7. Bansal, G., & Gefen, D. (2010). The impact of personal dispositions on information sensitivity, privacy concern and trust in disclosing health information online. *Decision support systems*, 49(2), 138-150.
8. Bastani, P., Bikineh, P., Mehralian, G., Sadeghkhani, O., Rezaee, R., Kavosi, Z., & Ravangard, R. (2021). Medication adherence among the elderly: applying grounded theory approach in a developing country. *Journal of Pharmaceutical Policy and Practice,* 14(1), 55.
9. Bastani, P., Bikineh, P., Mehralian, G., Sadeghkhani, O., Rezaee, R., Kavosi, Z., & Ravangard, R. (2021). Medication adherence among the elderly: applying grounded theory approach in a developing country. *Journal of Pharmaceutical Policy and Practice*, 14(1), 55.
10. Beldad, A., De Jong, M., & Steehouder, M. (2010). How shall I trust the faceless and the intangible? A literature review on the antecedents of online trust. *Computers in human behavior,* 26(5), 857-869.
11. Boeni, F., Hersberger, K. E., & Arnet, I. (2015). Success of a sustained pharmaceutical care service with electronic adherence monitoring in patient with diabetes over 12 months. *Case Reports,* 2015, bcr2014208672.
12. Borah, B. J., Qiu, Y., Shah, N. D., & Gleason, P. P. (2016, September). Impact of provider mailings on medication adherence by Medicare Part D members. In *Healthcare* (Vol. 4, No. 3, pp. 207-216). Elsevier.

13. Brath, H., Morak, J., Kästenbauer, T., Modre-Osprian, R., Strohner-Kästenbauer, H., Schwarz, M., ... & Schreier, G. (2013). Mobile health (mHealth) based medication adherence measurement–a pilot trial using electronic blisters in diabetes patients. *British journal of clinical pharmacology,* 76, 47-55.
14. Commins, J. (2010). Nurses say distractions cut bedside time by 25%. Health Leaders.
15. Criner, G. J., Cole, T., Hahn, K. A., Kastango, K., Eudicone, J., & Gilbert, I. (2021). The impact of budesonide/formoterol pMDI medication reminders on adherence in chronic obstructive pulmonary disease (COPD) patients: results of a randomized, phase 4, clinical study. *International Journal of Chronic Obstructive Pulmonary Disease,* 563-577.
16. Criner, G. J., Cole, T., Hahn, K. A., Kastango, K., Eudicone, J., & Gilbert, I. (2021). The impact of budesonide/formoterol pMDI medication reminders on adherence in chronic obstructive pulmonary disease (COPD) patients: results of a randomized, phase 4, clinical study. *International Journal of Chronic Obstructive Pulmonary Disease,* 563-577.
17. De Fauw, J., Ledsam, J. R., Romera-Paredes, B., Nikolov, S., Tomasev, N., Blackwell, S., ... & Ronneberger, O. (2018). Clinically applicable deep learning for diagnosis and referral in retinal disease. *Nature medicine*, 24(9), 1342-1350.
18. Dilsizian, S. E., & Siegel, E. L. (2014). Artificial intelligence in medicine and cardiac imaging: harnessing big data and advanced computing to provide personalized medical diagnosis and treatment. *Current cardiology reports*, 16, 1-8.
19. Dutta-Bergman, M. (2003). Trusted online sources of health information: differences in demographics, health beliefs, and health-information orientation. *Journal of medical Internet research*, 5(3), e893.
20. Elliott, R. A., Barber, N., Clifford, S., Horne, R., & Hartley, E. (2008). The cost effectiveness of a telephone-based pharmacy advisory service to improve adherence to newly prescribed medicines. *Pharmacy World & Science,* 30, 17-23.
21. Fittler, A., Lankó, E., Brachmann, B., & Botz, L. (2013). Behaviour analysis of patients who purchase medicines on the internet: can hospital pharmacists facilitate online medication safety?. *European Journal of Hospital Pharmacy: Science and Practice,* 20(1), 8-12.
22. Foreman, K. F., Stockl, K. M., Le, L. B., Fisk, E., Shah, S. M., Lew, H. C., ... & Curtis, B. S. (2012). Impact of a text messaging pilot program on patient medication adherence. *Clinical therapeutics,* 34(5), 1084-1091.
23. Graetz, I., McKillop, C. N., Stepanski, E., Vidal, G. A., Anderson, J. N., & Schwartzberg, L. S. (2018). Use of a web-based app to improve breast cancer symptom management and adherence for aromatase inhibitors: a randomized controlled feasibility trial. *Journal of Cancer Survivorship,* 12, 431-440.
24. Guadamuz, J. S., McCormick, C. D., Choi, S., Urick, B., Alexander, G. C., & Qato, D. M. (2021). Telepharmacy and medication adherence in urban areas. *Journal of the American Pharmacists Association,* 61(2), e100-e113.
25. Harbour, J., & Chowdhury, G. G. (2007). Use and outcome of online health information services: a study among Scottish population. *Journal of Documentation,* 63(2), 229-242.
26. Horáková, T., Houška, M., & Dömeová, L. (2017). Classification of the Educational Texts Styles with the Methods of Artificial Intelligence. *Journal of Baltic Science Education,* 16(3), 324-336.
27. Huang, C. Y., Nguyen, P. A. A., Clinciu, D. L., Hsu, C. K., Lu, J. C. R., Yang, H. C., ... & Li, Y. C. J. (2017). A personalized medication management platform (PMMP) to improve medication adherence: a randomized control trial. *Computer Methods and Programs in Biomedicine,* 140, 275-281.
28. Huang, C. Y., Nguyen, P. A. A., Clinciu, D. L., Hsu, C. K., Lu, J. C. R., Yang, H. C., ... & Li, Y. C. J. (2017). A personalized medication management platform (PMMP) to improve medication adherence: a randomized control trial. *Computer Methods and Programs in Biomedicine*, 140, 275-281.

29. Jha, S., & Topol, E. J. (2016). Adapting to artificial intelligence: radiologists and pathologists as information specialists. *Jama*, 316(22), 2353-2354.
30. Jiang, F., Jiang, Y., Zhi, H., Dong, Y., Li, H., Ma, S., ... & Wang, Y. (2017). Artificial intelligence in healthcare: past, present and future. *Stroke and vascular neurology*, 2(4).
31. Jones, S. S., Heaton, P. S., Rudin, R. S., & Schneider, E. C. (2012). Unraveling the IT productivity paradox—lessons for health care. *N Engl J Med,* 366(24), 2243-2245.
32. Karahoca, A., Karahoca, D., & Aksöz, M. (2018). Examining intention to adopt to internet of things in healthcare technology products. *Kybernetes,* 47(4), 742-770.
33. Kassavou, A., A'Court, C. E., Chauhan, J., Brimicombe, J. D., Bhattacharya, D., Naughton, F., ... & Sutton, S. (2020). Assessing the acceptability of a text messaging service and smartphone app to support patient adherence to medications prescribed for high blood pressure: a pilot study. *Pilot and feasibility studies,* 6, 1-14.
34. Kayaalp, M. (2018). Patient privacy in the era of big data. *Balkan medical journal,* 35(1), 8-17.
35. Kelly, C. J., Karthikesalingam, A., Suleyman, M., Corrado, G., & King, D. (2019). Key challenges for delivering clinical impact with artificial intelligence. *BMC medicine*, 17, 1-9.
36. Kobb, R., Hoffman, N., Lodge, R., & Kline, S. (2003). Enhancing elder chronic care through technology and care coordination: report from a pilot. *Telemedicine Journal and e-HEALTH,* 9(2), 189-195.
37. Kocher, R., & Sahni, N. R. (2011). Rethinking health care labor. *N Engl J Med,* 365(15), 1370-2.
38. Lancet, T. (2017). Artificial intelligence in health care: Within touching distance. *Lancet* (London, England), 390(10114), 2739.
39. LeCun, Y., Bengio, Y., & Hinton, G. (2015). *Deep learning. nature,* 521(7553), 436-444.
40. Lemire, M., Paré, G., Sicotte, C., & Harvey, C. (2008). Determinants of Internet use as a preferred source of information on personal health. *International journal of medical informatics*, 77(11), 723-734.
41. Mehzabin, M., & Moniruzzaman, M. (2019). Prospects and Challenges for E-Pharmacy in Bangladesh. *In MESSAGE FROM THE CONFERENCE CHAIRS* (p. 485).
42. Mooney, S. J., & Pejaver, V. (2018). Big data in public health: terminology, machine learning, and privacy. *Annual review of public health,* 39(1), 95-112.
43. Ownby, R. L., Hertzog, C., & Czaja, S. J. (2012). Tailored information and automated reminding to improve medication adherence in Spanish-and English-speaking elders treated for memory impairment. *Clinical gerontologist,* 35(3), 221-238.
44. Patel, V. L., Kannampallil, T. G., & Kaufman, D. R. (2015). Cognitive Informatics for Biomedicine. *Human Computer Interaction in Healthcare*, 2015.
45. Patel, V. L., Shortliffe, E. H., Stefanelli, M., Szolovits, P., Berthold, M. R., Bellazzi, R., & Abu-Hanna, A. (2009). The coming of age of artificial intelligence in medicine. *Artificial intelligence in medicine,* 46(1), 5-17.
46. Picardi, C., Hawkins, R., Paterson, C., & Habli, I. (2019). A pattern for arguing the assurance of machine learning in medical diagnosis systems. In *Computer Safety, Reliability, and Security: 38th International Conference, SAFECOMP 2019, Turku, Finland, September 11–13, 2019, Proceedings* 38 (pp. 165-179). Springer International Publishing.
47. Punj, G. (2012). Income effects on relative importance of two online purchase goals: Saving time versus saving money?. *Journal of Business Research,* 65(5), 634-640.
48. Rains, S. A. (2007). Perceptions of traditional information sources and use of the world wide web to seek health information: findings from the health information national trends survey. *Journal of health communication,* 12(7), 667-680.
49. Sampene, A. K., Li, C., & Wiredu, J. (2024). Unravelling the shift: exploring consumers' adoption or resistance of E-Pharmacy through behavioural reasoning theory. *BMC Public Health,* 24(1), 2789.

50. Shruthi, R., Jyothi, R., Pundarikaksha, H. P., Nagesh, G. N., & Tushar, T. J. (2016). A study of medication compliance in geriatric patients with chronic illnesses at a tertiary care hospital. *Journal of clinical and diagnostic research: JCDR,* 10(12), FC40.
51. Song, J. (2007). Trust in health infomediaries. *Decision support systems*, 43(2), 390-407.
52. Toscos, T., Drouin, M., Pater, J. A., Flanagan, M., Wagner, S., Coupe, A., ... & Mirro, M. J. (2020). Medication adherence for atrial fibrillation patients: triangulating measures from a smart pill bottle, e-prescribing software, and patient communication through the electronic health record. *JAMIA open,* 3(2), 233-242.
53. Urbanavičiūtė, I. (2022). *The impact of attitude towards e-pharmacy brand on the intention to repurchase cosmetics in the online pharmacy* (Doctoral dissertation, Vilniaus universitetas.).
54. Van Wynsberghe, A. (2021). Sustainable AI: AI for sustainability and the sustainability of AI. *AI and Ethics,* 1(3), 213-218.
55. Vilasi, A., Panuccio, V., Morante, S., Villa, A., Versace, M. C., Mercuri, S., ... & Torino, C. (2020, December). Smit-Ckd: A Mobile App To Improve Adherence To Therapy In Ckd Patients. A Pilot Study. In 2020 *IEEE International Conference on Bioinformatics and Biomedicine (BIBM)* (pp. 1492-1497). IEEE.

Human Following Robot Using Arduino

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ABSTRACT

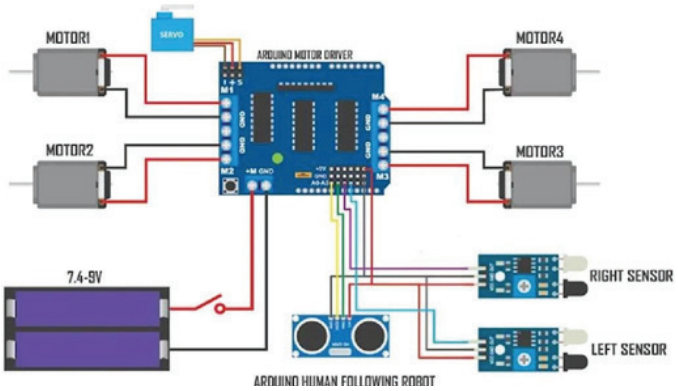
An Arduino-powered human-following robot is an autonomous device made to locate and follow a human target. This creative robot ensures smooth tracking and navigation by using ultrasonic and infrared sensors to detect and measure the target's distance. The brain of the system is the Arduino microcontroller, which processes sensor data and uses motors and motor drivers to control the robot's movement. By ensuring obstacle recognition and avoidance, the robot's programming improves its operational efficiency in dynamic situations. These robots can be used for a variety of tasks, such as personal support, industrial automation, and helping the elderly and those with disabilities. This project's use of affordable components, such as Arduino, makes it the perfect answer for the development of practical robotics and promotes creativity in tackling real-world problems. It is a major step towards more reasonably priced autonomous systems since ongoing advancements in programming and sensor precision allow for even greater performance improvements.

***Keywords**: Arduino, human-following robot, autonomous navigation, ultrasonic sensor, obstacle avoidance.*

INTRODUCTION

An Arduino-powered human-following robot is a cutting-edge robotic device that can track and follow a human target on its own. In order to provide an useful and an affordable solution for assistance in a variety of applications, this project integrates robots, sensors, and programming. By continuously measuring the distance and reacting appropriately, the system uses ultrasonic or infrared sensors to identify a person's position and movement. The Arduino microcontroller, which is at the heart of the design, interprets sensor data and regulates the robot's motors to provide accurate navigation and obstacle avoidance. There are several practical applications for this technology, including helping the elderly or those with disabilities, carrying heavy objects in industrial environments, and acting as a personal assistant. Arduino-based platforms are perfect for putting such systems into place because of their ease of use, cost, and versatility, which encourages innovation and creativity in robotics and automation. This robot is an advancement in the accessibility of autonomous systems.

CIRCUIT DIAGRAM



BODY

The Arduino-powered human-following robot is made up of a number of essential parts, each of which is vital to its functioning. The Arduino microcontroller, which functions as the brain of the robot and processes sensor data to carry out control orders for movement and navigation, is at the center of the system. By sending out ultrasonic waves and timing how long it takes for them to bounce back after striking an item, the ultrasonic sensors—which are usually positioned on the robot's sides and front—are able to identify the human target. The target's position and distance are determined using this data. DC motors or servo motors, which are managed by a motor driver module, power the robot. In order to guarantee accurate movement and speed control, the motor driver serves as a link between the Arduino and the motors, boosting control signals. Smooth mobility over a variety of terrains is made possible by wheels or tracks that are connected to the motors. Furthermore, a battery pack ensures portability by supplying the power required to operate the complete system. Some robots come equipped with a Bluetooth module for wireless communication to improve functionality. This enables the operator to manage the robot from a distance when necessary. In order to prevent collisions while the robot is following the target, obstacle detection is accomplished utilizing sensors such as infrared or extra ultrasonic modules.

The human-following robot operates on the basis of feedback control and distance measuring. The Arduino receives the distance information from the ultrasonic sensors as they continuously search for the closest object (the human target). After processing this data, the microcontroller produces control signals that modify the direction and speed of the motors. The robot follows the predetermined logic to dynamically adjust its position and maintain a safe distance while the target moves, guaranteeing precise and seamless tracking.

CONCLUSION

The Arduino-based human-following robot demonstrates how sensors, microcontrollers, and robotics may be combined to produce an efficient and cost-effective system for autonomous human tracking. Its practical applications in assistance and automation highlight its potential to improve daily life and industry by encouraging innovation and by investing into robotic technologies.

References :

1. K. Morioka, J.-H. Lee, and H. Hashimoto, “Human-following mobile robot in a distributed intelligent sensor network,” IEEE Trans. Ind. Electron., vol. 51, no. 1, pp. 229–237, Feb. 2004.
2. International Research Journal of Modernization in Engineering Technology and Science (Peer-Reviewed, Open Access, Fully Refereed International Journal)
3. H. Takemura, N. Zentaro, and H. Mizoguchi, “Development of vision-based person following module for mobile robots in/outdoor environment,” in 2009 IEEE International Conference on Robotics and Biomimetics (ROBIO), 2009
4. N. Bellotto and H. Hu, “Multisensor integration for human-robot interaction,” IEEE J.Intell. Cybern. Syst., vol. 1, no. 1, p. 1, 2005
5. T. Yoshimi, M. Nishiyama, T. Sonoura, H. Nakamoto, S. Tokura, H. Sato, F. Ozaki, N. Matsuhira, and H. Mizoguchi, “Development of a Person Following Robot with Vision Based Target Detection,” in 2006 IEEE/RSJ International Conference on Intelligent Robots and Systems, 2006, pp. 5286–5291.
6. Muhammad Sarmad Hassan, MafazWali Khan, Ali Fahim Khan,”Design and Development of Human Following Robot”, 2015,Student Research Paper Conference,Vol-2, No-15.

AI : From the Perspective of Human Rights and Cybersecurity

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ABSTRACT

The rapid enhancement of AI has transformed the whole world into a convenient and simple approach. With its emergence, every sector has faced growth, sustainability, and an approach of unprecedented advancements. It arose from advantageous implications to alarming threats raising ethical, complex, legal and humanitarian challenges. This paper critically examines the intersection and coherence of AI, human rights, and its impact on cybersecurity. It well defines and diminishes the ethical, cultural, political segregationthrough a combined approach providing a platform of engagement and address of cybersecurity threats and the preservation of human rights. As AI continues to permeate various sectors, from healthcare to finance, manufacturing to transportation, its integration introduces complexities that
brought forth new challenges, particularly in the realm of cybersecurity. Through AI, the human capabilities have surged to unprecedented levels, offering immense opportunities for innovation and advancement.Thus, this paper elucidates key challenges and opportunities in securing AI-driven systems, offering insights in mitigating cybersecurity threats and challenges.

Keywords – *artificial intelligence, human rights, cyberspace, digitalthreats, privacy*

INTRODUCTION

The transformation of AI has transformed the digital era and revolutionised the proliferation of technology. AI promises enhanced efficiency, decision-making, and automation, it also presents novel attack vectors and vulnerabilities, potentially amplifying the impact of cyber threats.As AI continues to permeate various sectors, from healthcare to finance, manufacturing to transportation, its integration introduces complexities that demand vigilant attention (Ibegbulam, et al., 2023; Abrahams, et al., 2024).In the digital age, the intersection of artificial intelligence (AI) and cybersecurity represents a pivotal nexus where innovation meets vulnerability. AI, with its ability to analyse vast amounts of data, identify patterns, and make autonomous decisions, has transformed industries and revolutionized countless aspects of our lives (Csernatoni, &Mavrona, 2022; Vaseashta, 2022; Roba Abbas, et al., 2022). With the advent of AI, one can anticipate the probable threats and provides a strategy to drive them away, based on historical data and real-time monitoring. Furthermore, AI-powered threat intelligence platforms continuously analyse global cyber threats, providing organizations with timely insights into evolving tactics, techniques, and procedures employed by malicious actors. This proactive approach empowers defenders to stay one step ahead of adversaries, fortifying their cyber defences and reducing the likelihood of successful attacks (Familoni, 2024). However, the integration of AI in cybersecurity possesses significant risks and threats. It requires additional attention to mitigate them. From deepfake technology, which uses AI algorithms to create realistic but fabricated audio, video, or text content, can be weaponized for malicious purposes to spreading disinformation, impersonating individuals, or manipulating public opinion.In sectors such as

critical infrastructure, healthcare, and transportation, where AI-powered systems control vital processes and services, the potential impact of cyber-attacks extends beyond data breaches to encompass physical harm and societal disruption (Dawodu, et al., 2023; Sobana, et al., 2022).Despite these challenges, this intersection offers immeasurable opportunities for innovation, invention, and evolution. By channelizing the power of AI-driven analytics, automation, and threat intelligence, organizations can strengthen their cyber defences and adapt to evolving threats with agility and precision. Through a proactive and multidisciplinary approach, we can harness the transformative potential of AI to safeguard digital assets, protect privacy, and preserve trust in an increasingly interconnected world.In conclusion, the convergence of AI and cybersecurity provides a defensive strategy to alleviate the threat of new vulnerabilities and risks.

HUMAN RIGHTS DIMENSION IN CYBERSECURITY

The human rights dimension of cybersecurity examines the interplay between safeguarding digital systems and protecting fundamental human rights. In an increasingly interconnected world, cybersecurity practices must align with international human rights standards to ensure technology protects individuals' freedoms rather than undermines them.Human rights are discussed as part of the framework but the prevailing understanding of what constitutes cybersecurity remains heavily focused on the level of sovereign state – its territory and its infrastructure – rather than the individual. This phenomenon can be understood from an international relations perspective as a realpolitik approach to governance when state interests are privileged, and a military-centric approach to the issue prevails. While these perceptions differ depending on the country and regional context, the realist cybersecurity view has been dominant in the cybersecurity decision-making (Pavlova, 2020). This article analyses the human rights dimension of security as a prerequisite for designing a comprehensive cybersecurity framework.Efficient translation of human rights standards into cyberspace realm needs to be ensured together with greater regulation and accountability. Beyond creating adequate legal and regulatory protection, building necessary awareness and skills for digital security is a measure of key importance.Consequently, the human rights dimension faces downward pressure – making the contested human rights in the cyberspace – such as the right to privacy, the right to freedom of expression and information, the right to association and assembly – into a secondary concern (Taddeo, 2013). Effective cybersecurity enhances cybersecurity through various ways like protecting personal data from any breach, securing platforms for individuals to communicate, cancelling unauthorised surveillance and providing a critical infrastructure to mitigate cybersecurity threats. AI provides a balanced approach of cybersecurity with human rights ensuring protection without undermining the rights. Cybersecurity measures must be inclusive, addressing the needs of marginalized and vulnerable communities and should align with human rights norms.Cybersecurity is the preservation – through the law, policy, technology, and education – of the availability*, confidentiality* and integrity* of information and its underlying infrastructure to enhance the security of persons both online and offline (*as defined by International Organization for Standardization (ISO) 27000 standard) (FOC, 2015). This definition promotes cybersecurity as a concept which recognises basic rights and fundamental freedoms as its core component

PROTECTING HUMAN RIGHTS THROUGH GLOBAL COOPERATION IN CYBERSPACE

Cyberspace has a proximate relationship between international cooperation and human rights. Its security, access, and development depend on effective collaboration among global players. The major issue is the infringement of the right to privacy which is enshrined in Universal Declaration of Human Rights (UDHR) which is under constant threat in cyberspace.Hildebrandt (2013, 2) proposes to understand this complex right as ‘the freedom from unreasonable constraints on identity construction, while taking into account that a number of other fundamental rights are at stake, notably data protection, non-discrimination, due process and free speech’. This statement illustrates that the right to privacy is instrumental in exercising a range of

individual and political rights. The right to privacy is included in Article 12 of the Universal Declaration of Human Rights (UN 1948) and Article 17 of the International Covenant on Civil and Political Rights (UN 1966), but its wording is limited to the prohibition of arbitrary or unlawful interference with one's privacy and the right for protection of the law against such interference or attacks. For instance, the European Convention on Human Rights (ECHR 2003) includes provisions for the rights to privacy in Article 8 stating that interference with the right by a public authority can only occur if '*it is in accordance with the law; and, necessary in a democratic society in the interests of national security, public safety or the economic well-being of the country, for the prevention of disorder or crime, for the protection of health or morals, or for the protection of the rights and freedoms of others'* (Pavlova, 2020). The cyberspace provides an engaging platform for the individuals to participate in free speech, activism, and access to information. However, the complications lie when the internet censorship, content regulationand disinformation threaten this right to freedom of speech.Cyberspace is a borderless domain, and unilateral approaches are insufficient to tackle transnational issues such as cybercrime, data protection, and digital inequality. The collaborative mechanisms of multinational organisations foster transparency and promote accountability and fairness in cyberspace governance. International collaboration must strike a balance between protecting cybersecurity and upholding human rights. Overreach in cybersecurity measures, such as mass surveillance or internet shutdowns, often results in human rights violations. Consequently, cybersecurity measures must be proportionate to the threat and avoid unnecessary inflictions and provide a framework of supportive international cooperation.

THE ROLE OF AI IN MODERN CYBERSECURITY

Stimulation of human intelligence processes as artificial intelligence are mainly done by machines, especially computers. They mainly consist of thinking, learning, and correcting themselves. AI plays a major role in creating cybersecurity systems which will recognize, intercept, and respond to threats without certainly interacting with humans. AI is an integral part in detecting the threats in cybersecurity. It helps in rapidly examining massive amount of data to fight against cyber threats. AI can rapidly detach damaged systems, prevent any kind of malicious communications, and initiate recovery. It can thoroughly analyse any unusual activity. AI can also successfully detect insider threats and compromised accounts. It can analyse malware activities to recognize new and unique threats.AI can enable faster and more efficient responses by identifying the threats at an early stage and reducing potential damage caused by an attack. Automated systems give AI an advantage to immediately response to detected threats, reducing the time between detection and mitigation. AI- enabled threat intelligence platforms can aggregate data from different sources such as, Open SourceINTelligence(OSINT), dark web monitoring, and internal security logs for providing a comprehensive view of the threat landscape. AI can always monitor and examine how users interact with applications, the frequency and timing of login, and the types of devices used. Organizations must ensure that AI tools are designed and implemented in ways that comply with data privacy regulations typically the General Data Protection Regulation(GDPR). AI helps organizations stay active against cyber threats without overwhelming security teams with false alarms. This helps the cyber security teams to stay ahead of upcoming threats and take precautions before an attack emerges. The use of AI-powered Security Information and Event Management(SIEM) systems helps in facilitating real-time monitoring of vast amounts of security data, allowing the system to detect potential threats. Machine Learning models can analyze patterns of normal network traffic and behaviour, which in turn allows them to identify malware that may indicate a hidden threat.

MITIGATING CYBERSECURITY THREATS USING THE HELP OF AI

High profile ransomware attacks like those on the Colonial Pipeline (May 2021) and the attack on the City of Baltimore(2019) are the highlights of the devastating impact of malware on public services. According

to Anti- Phishing Working Group(APWG) phishing attacks surged in 2020 with over 2,00,000 unique phishing sites detected in the first quarter alone. Advanced Persistent Threats(APT) are stealthy and focuses to infiltrate and persist within a network for extended periods. The prime example of this is the SolarWinds hack 2020, which affected the majority of the U.S government agencies and private companies. Denial of Service(DoS) and Distributed Denial of Service(DDoS) Attacks are designed to overwhelm the systems and making them inaccessible. These attacks have significantly increased in 2020, with one attack reaching 2.3 terabits per second, making the largest DDoS attacks ever recorded (Conger, 2019). To prevent the increasing flood of complicated cyber-attacks, AI helps in providing powerful tools and methods. It helps in protecting any kind of sensitive data, maintaining system integrity, and ensuring business continuity. Risk Assessment should be conducted regularly to identify any malware in the system and the network. Threat intelligence tools should be used to stay informed about the methods used by the cybercriminals to breach the security. It should be ensured to daily update all operating systems, applications and devices for preventing any breach of securities. The patch management process should be automated to minimize the risk of missing any critical updates. AI can detect minor symptoms of compromise such as strange behaviors and activities during data transfers by continuously monitoring and observing interactions. Sensitive data should always be encrypted to protect it from unauthorized access. Strong encryption should be used and daily review should be done to ensure they meet the security guidelines. End-to-end encryption should be mandatory for communicating and sharing files to reduce and risks. AI can also predict flaws by using past records and data. Organizations can reduce risks by focusing on high- risk factors and addressing the necessary concerns first. It can conduct frequent cybersecurity training to educate the employees and provide them knowledge regarding the common cyber threats. It encourages employees to report unusual activities and reduce the risks in the organizations. It maintains a culture of cybersecurity awareness in the overall organizations. Multi-Factor Authentication(MFA) has become the best practice for securing sensitive accounts and systems mainly after high profile breaches like the Twitter hack on July, 2020. It is necessary to timely patch the software and the systems. In2021, Hafnium attack, cybercriminals affected thousands of organizations globally by exploiting the vulnerabilities of the software. According to a report by Cybersecurity and Infrastructure Security Agency(CISA), the most common tactics used by the cyber attackers are the exploitation of unpatched vulnerabilities (CISA,2021).

FUTURE OF AI IN THE FIELD OF CYBERSECURITY

AI has immense potential in the field of cybersecurity. AI has revolutionized cybersecurity, providing strong capabilities to battle new threats. Over the past decade the role of AI in the cybersecurity has significantly increased. According to a report from MarketsandMarkets, 2023, the AI in cybersecurity market in expected to grow from $21.8 billion to $48.1 billion by 2028, signifying the immense growing of AI in this area. In the upcoming future, AI will become more efficient in generating predictive threat intelligence. Furthermore, AI will likely become the core part of threat intelligence platforms by 2026, enabling organizations to gather, analyse, and act upon real time data more efficiently(Garg, 2023). By 2028, AI- driven Security Orchestration, Automation, and Response(SOAR) platforms will be fully integrated into cybersecurity operations. These platforms will not only help in detecting and analysing threats in real time but will also help in taking instant actions to neutralize them. Automated incident response will allow the AI to block malicious traffics, and begin the recovery process without human interaction. It is also expected that by 2025, AI-powered threat actors will be using machine learning models to instantly adapt to their attack modes so that it can make them harder to detect and mitigate. To counter and prevent from these threats cybersecurity professionals will rely on AI systems which are capable of learning and adapting to new attack methods and patterns in real time. By 2027, AI-driven models are expected to adjust to new threat environments and anticipate cybercriminal tactics in real time. In 2022, a research collaboration between major healthcare organizations and AI firms demonstrated how federated learning could enhance medical

diagnoses without centralizing patient data, ensuring compliance with health data privacy regulations like HIPAA(Health Insurance Portability and Accountability Act) in the U.S. (MIT,2022). Organizations like IBM and Palo Alto Networks are already integrating AI-driven threat detection into their platforms, which are benefiting them in various ways. It will require security analysts to not only manage AI tools but also interpret and respond to the insights provided by those tools. The demand for cybersecurity professionals with the knowledge of AI are expected to rapidly grow in the upcoming years, with a projected shortage of over 3.5 million cybersecurity workers globally by 2025. The future of AI is very promising, with lots of potential to revolutionize threat detection, prevention, and secured data. By 2030, AI driven systems will play an integral role in identifying emerging threats, automated responses, and enhancing overall security resilience.

References :

1. Csernatoni, R., &Mavrona, K. (2022). The artificial intelligence and cybersecurity nexus: Taking stock of the European Union's approach. *EU Cyber Direct*. https://eucd.s3.eu-central-1.amazonaws.com/eucd/assets/HAycHo-M/the-ai-and-cybersecurity-nexus-taking-stock-of-the-eu-s-approach.pdf
2. Conger, K., Fausset, R., & Kovaleski, S. F. (2019, May 14). San Francisco bans facial recognition technology. *The New York Times.* https://www.nytimes.com/2019/05/14/us/facial-recognition-ban-san-francisco.html
3. Dawodu, S. O., Omotosho, A., Akindote, O. J., Adegbite, A. O., &Ewuga, S. K. (2023). Cybersecurity risk assessment in banking: Methodologies and best practices. *Computer Science & IT Research Journal,* 4(3), 220–243.
4. Familoni, B. (2024). Cybersecurity challenges in the age of AI: Theoretical approaches and practical solutions. *Computer Science & IT Research Journal,* 5(3), 703–724. Fair East Publishers. https://www.fepbl.com/index.php/csitrj
5. Freedom Online Coalition (FOC). (2019). WG1 launches recommendations on human rights-based approaches to cybersecurity. Freedom Online Coalition. https://freeandsecure.online
6. Garg, R., & Devi, J. (2023). Empowering cybersecurity: A deep dive into AI-driven security intelligence modelling. *i-Manager's Journal on Information Technology,* 12(4), 1–6.
7. Hildebrandt, M. (2013). Balance or trade-off? Online security technologies and fundamental rights. *Philosophy & Technology,* 26(4), 357–379. https://doi.org/10.1007/s13347-013-0104-0
8. Ibegbulam, C. M., Olowonubi, J. A., Fatounde, S. A., &Oyegunwa, O. A. (2023). Artificial intelligence in the era of 4IR: Drivers, challenges, and opportunities. *Engineering Science & Technology Journal,* 4(6), 473–488.
9. Pavlova, P. (2020). Human rights-based approach to cybersecurity: Addressing the security risks of targeted groups. *PHRG Peace Human Rights Governance,* 4(3).
10. Taddeo, M. (2013). Cybersecurity and individual rights: Striking the right balance. *Philosophy & Technology,* 26(4), 353–356. https://doi.org/10.1007/s13347-013-0140-9

A Modern Approach towards Optimizing Cyber-Physical Systems' Resilience and Integrity with Careful Evaluation using AI tools

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ABSTRACT

The numerous internal and external aspects affecting the dependability of cyber-physical systems (CPSs) are examined in this research. It presents a thorough approach that integrates technology frameworks and procedures for testing and assessing CPS reliability. In addition to evaluating performance reliability that encompasses service, cybersecurity, resilience, elasticity, and vulnerabilities, the focus is on evaluating the dependability of components across hardware, software, and architecture. A comprehensive perspective of system dependability is provided by a synthesis approach that uses multi-index approaches to combine these disparate aspects into four important performance reliability indices. The goal of the suggested approach is to greatly improve the thorough and continuous examination of CPSs.

INTRODUCTION

Cyber-physical systems (CPSs), introduced in 2006, represent the integration of computational algorithms with physical processes.. These systems are becoming increasingly essential to various foundational services and industries that support daily life and operations. Given their pervasive deployment, ensuring reliability and safety is paramount for CPSs The systems' interdependence and ability to propagate failures among themselves might have disastrous effects if they fail or are attacked. Inadequate comprehension of failure mechanisms and inadequate testing and verification lead to frequent failures and accidents. Therefore, it is crucial to investigate the causes of failures, guarantee system security and safety, and recover and get better after mistakes. Diverse viewpoints have been used in research on CPS testing and analysis. The reliability of CPS software is examined by formal modelling , qualities that are static , and dynamic verification. To test and validate during the development process, modeling and testing techniques such as agent-based modeling, physical-entity service-oriented models, and the integration of diverse models are employed for verification and testing. A variety of quantitative analysis tools are used to study cyberattacks, including attack trees and various graph-based models. Additionally, the cyber risk of CPSs is assessed using hierarchical holographic modeling (HHM) and probability risk assessment (PRA).. It has been observed that current research tends to overlook a comprehensive solution for the entire system, focusing instead on analyzing and testing individual components or key performance aspects.. Consequently, this research examines both internal and external factors that influence the dependability of CPS.

OBJECTIVES

This research analyses the factors from within and outside that influence the reliability of CPSs.. Taking into account the technological framework and procedures, a method for assessing and testing the dependability of CPSs is proposed. The framework includes a comprehensive reliability assessment of the entire system, along with tests and evaluations of its components, functionality, security measures, adaptability, and potential weaknesses The testing indices and methods are demonstrated in the processes of implementation.

IMPACT ELEMENTS ON THE DEPENDABILITY OF CPS

The primary determinants of CPS safety and dependability are failures, which are classified as internal and external.

A. Internal Factors

Failures originating from within the CPS are referred to as internal factors. These include malfunctioning operational rules, flawed architectures, software bugs, and hardware malfunctions. Software and hardware are the fundamental components of CPSs. Hardware has software with calculating functions built in. Through wire or wireless networks, several components come together to realize functions like perception, link, calculation, and control . It is clear that for CPSs to operate properly, hardware and software are required. A network's topology and capacity allocation are defined by its architecture. System failures can also be caused by flawed architectures. Transportation faults can arise, for instance, if nodes that are susceptible to electromagnetic interference are grouped together in an irrational topological arrangement. Alternatively, a lack of capacity is probably going to result in traffic jams, delays, and/or data loss. The system's predetermined methods for responding to its own conditions and perception of its surroundings are known as operating rules. A flawed rule design will undoubtedly result in problems, just like with the architecture. The Western Systems Coordinating Council (WSCC) blackout, for example, was caused by faulty regulations. One trip caused the system to suddenly collapse due to an abrupt change in tide, significant voltage fluctuations, equipment overload, and equipment overload.

B. External Factors

The operating modes, environmental factors, and external attacks are examples of external elements that originate from outside the CPS and have an impact on the internal issues of the systems.

Environmental components include both social and natural conditions. Physical, chemical, and biological factors influencing the system are referred to as the natural environment. Under the impact of nature, hardware failures including wear, corrosion, and aging will happen. The external attack is malicious devastation from outside CPSs. Because of their direct connection to the internet, CPSs are vulnerable to dangerous cyberattacks such as worm viruses, distributed denial of service attacks, and assaults on routers or Domain Name Systems (DNSs).

THE TECHNICAL FRAMEWORK

Taking into account all the elements discussed, a technology framework is proposed that classifies internal aspects as objectives and external aspects as conditions, as shown in Fig. 1.

The evaluation and testing process consists of three components: structured analysis, dependability testing, and extensive assessment.

At the outset, a comprehensive review of both internal and external factors that impact the system’s dependability is vital, as it establishes the groundwork for subsequent initiatives.

Subsequently, dependability testing comprises two elements: component reliability and performance reliability. The former focuses on evaluating the reliability of system components, including physical devices, software, and network design. Ensuring the quality of operations and measuring the reliability of these components is essential before proceeding with performance reliability testing..

Cybersecurity, resilience, adaptability, susceptibility, and service quality are among the Cyber-Physical Systems (CPS) performance criteria. Over time, CPSs' performance characteristics change along with their architecture and environmental circumstances

It is recommended that performance reliability be the primary criterion used to assess the long-term operational quality of Cyber-Physical Systems (CPSs)

Functional benchmark and Performance metric:

Let's consider two parameters, P and Pth. A component or system is deemed to have failed if P≥Pth . Here, P is known as the performance parameter, while Pth is referred to as the functional benchmark

Performance Reliability The ability of a performance parameter P to reach or exceed the threshold Pth in a specified amount of time or through a prearranged mission scenario (or group of scenarios) in a realistic operational environment is known as performance reliability. Consequently, service reliability, cybersecurity reliability, resilience and adaptability reliability, and vulnerability reliability are all included in the performance reliability measurements for Cyber-Physical Systems (CPSs)

Each parameter's performance reliability is quantified by measuring values at predetermined intervals using accepted techniques, then statistically analysing the results.

In conclusion, a comprehensive analysis of the four performance reliability indicators is carried out in order to evaluate the overall reliability of the system. Comprehensive explanations of the testing methods are given in the sections that follow. Performance reliability testing is covered in Parts D through G, while component reliability testing is the main focus of Parts I through III. Part VIII includes a thorough assessment of the system as a whole.

I. Testing for Hardware Reliability

Hardware in Cyber-Physical Systems (CPSs) can be categorized into electronic and non-electronic products. Various metrics, including failure rate, Mean Time Between Failures (MTBF), and Mean Time To Failure (MTTF), are typically chosen to assess reliability based on product type, testing objectives, data sources, and sample sizes. Common methods for evaluating hardware reliability include experimental approaches, comparisons with similar products, Delphi techniques, and stress analysis.

II. Software Reliability Testing

Software reliability testing is primarily conducted prior to deployment, focusing on safety and compatibility. Reliability analysis methods include Fault Tree Analysis (FTA) and Petri nets, along with formal modeling techniques that rely on model validation and theorem proving. Additionally, direct testing methods are used for safety evaluation, which are based on error guessing and interface grammar. Compatibility testing is intended to ensure that the software works effectively with hardware and other software systems.

III . Connectivity Reliability Testing

The network architecture serves as the foundation for Cyber-Physical Systems (CPS) to share resources, connecting various units for data exchange and collaboration. Connection reliability indicates whether the architecture is sufficiently robust to support system operations. This reliability can decrease due to network disconnections. Here, "network" encompasses not just the communication systems but also all interconnected structures that facilitate the transfer of materials and information. For instance, in logistics networks, road disruptions can negatively impact connection reliability. If goods are delivered late or to incorrect locations, it compromises the overall performance reliability of the system.

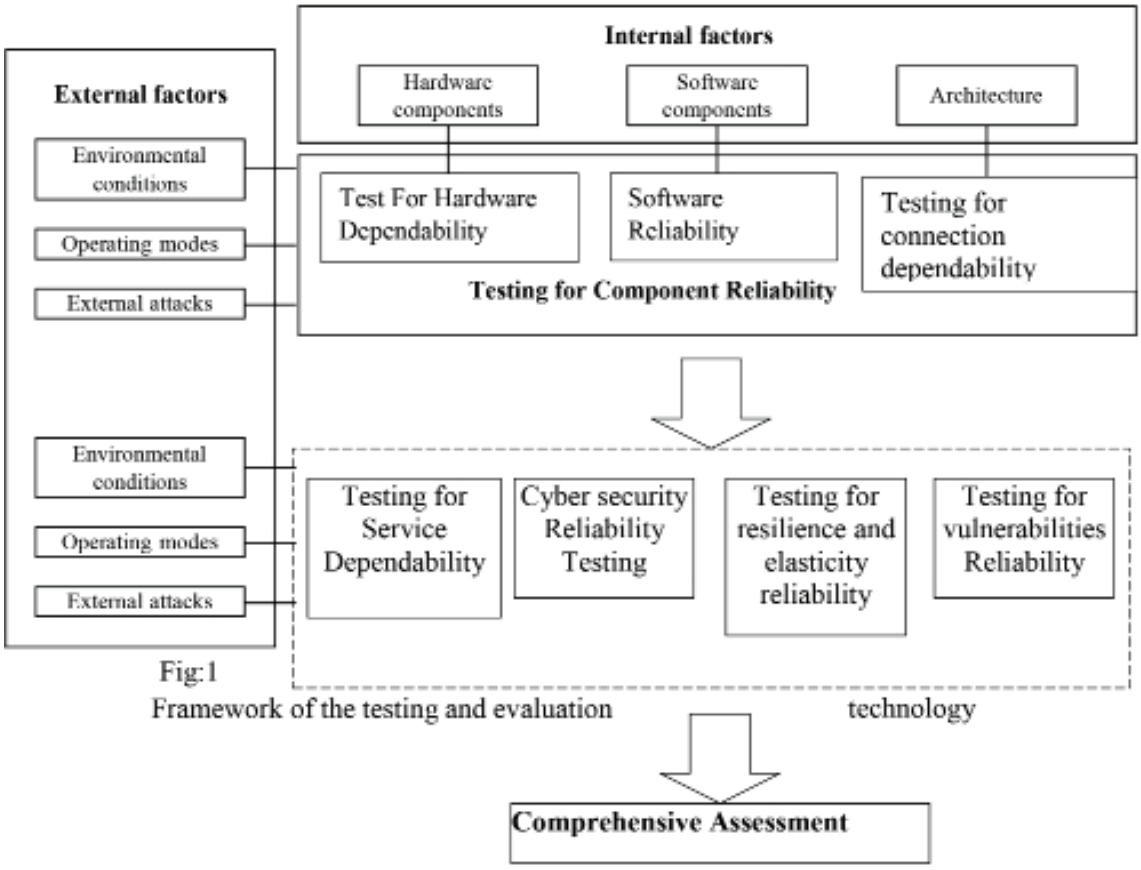

Fig:1
Framework of the testing and evaluation technology

ASSESSING SERVICE RELIABILITY

CPSs are capable of providing a variety of services. So there are several parameters to reflect service quality, such as time delay and error rate for networks and communication, CPU utilization for data centres, and so on. The most efficient technique to verify service reliability is to monitor all of the required indicators throughout operational time and statistically analyse the data.

EVALUATING CYBER SECURITY RELIABILITY

Cybersecurity testing typically involves overseeing system usage, which includes monitoring for cyber-attacks, detecting unusual behaviours, and conducting real-time security assessments. The process unfolds as follows

Firstly to develop an assessment model based on potential threats, system trustworthiness, and the importance of assets. Secondly to gather information related to these three aspects to proceed with the evaluation. The necessary information is gathered through an analysis of network attacks, system vulnerabilities, and asset characteristics. Next, the likelihood of system failure or performance degradation is determined based on identified threats and system reliability, while potential losses are estimated according to asset value. Using the assessment model, the security status of the target nodes is calculated. Finally, use the hierarchical

evaluation model to evaluate the system's security grade based on node relevance. This paradigm follows a bottom-to-top evaluation policy, with a focus on local and global perspectives. Using a set of cyber security testing variables and a threshold based on security demands, performance reliability is calculated over time

EVALUATING RESILIENCE AND ELASTICITY RELIABILITY

Elasticity refers to a system's capacity to adjust its configuration and resources to meet changing needs (Proceedings of the 2015 IEEE IEEM 1003). Resilience refers to a system's ability to react to faults and continue operating under predicted and unforeseen conditions. Profile testing involves loading various profiles onto the system to monitor its behaviour. This method effectively evaluates the system's elasticity. As illustrated in Fig. 2, different requirements—such as increasing or decreasing the load and scaling in or out—are introduced into the profiles. The system's elasticity is determined based on the quality of its responses.

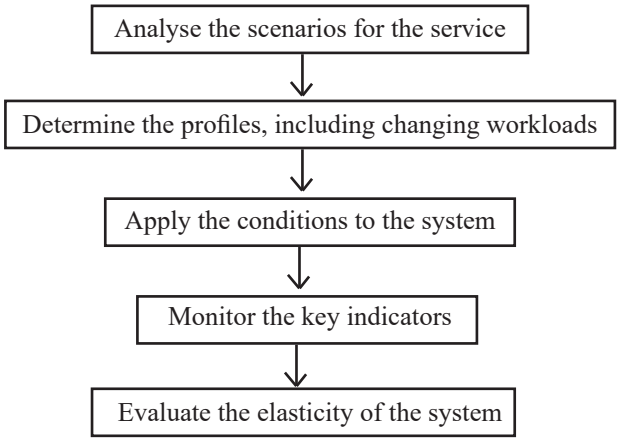

Fig. 2 Testing elasticity with profiles

Fault injection is a validation technique for fault-tolerant systems that involves conducting controlled experiments to observe system behaviour when faults are deliberately introduced. Faults are injected into the system to simulate failure scenarios. Fault injection methods can be categorized based on fault type—either hardware-based or software-based—and by approach, as either simulation-based or physical-based, depending on whether virtualization is involved. Resilience is assessed by monitoring the system's response to failures and disruptions, making fault injection an effective tool for evaluating resilience. The process of resilience testing is illustrated in Fig. 3.

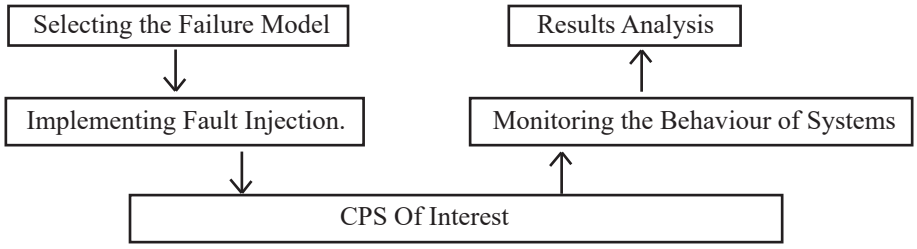

Fig:3 Resilience Testing Process

1. **Choose the failure models**
   Identify the inputs for the target system and transfer the selected failure modes to the next injection stage. The closer these chosen modes align with real-world scenarios, the more precise the results will be.
2. **Introduce the faults**
   Inject failure modes from the previous step into the target system using appropriate mechanisms.
3. **Observe the system's behaviour**
   Monitor system behaviour based on testing objectives. Typical post-injection episodes include successful fault injection, detection, system recovery, and failure behaviour.
4. **Analyse the findings**
   A comprehensive test consists of independent experiments, each covered by four steps. When conducting a detailed test, it's important to consider the aims and confidence as the ultimate goal. Most evaluation methods rely on probability and statistics.

VULNERABILITY ASSESSMENT RELIABILITY

CPSs are robust but fragile. Small incidents can lead to catastrophic outcomes due to failure propagation, making CPSs extremely vulnerable. Vulnerability is determined based on the likelihood of CPSs failing or being attacked.

CPSs are characterized using complex network theory.

Nodes represent system elements, while edges abstract the interactions between units. The susceptibility of the CPS is studied and analysed using complex network theory [27]. The phases are presented as follows.

1. **Preparation**
   Identify all potential external threats and failure modes relevant to the CPS. Next, create a knowledge base documenting the failure behaviours of the CPS.
2. **System Modelling**
   Develop models of the network architecture and functional components of the CPS. These two aspects represent fundamental characteristics of the system and serve as inputs to understand its failure mechanisms.
3. **Analysis of system failure behaviour**
   Analyse the nature of system failure behaviours using system models and relevant inputs. Li Daqing's analysis of collected data reveals that traffic congestion in cities and power grid failures exhibit long-range spatial correlations, with these correlations diminishing gradually over distance
4. **Analyze and calculate vulnerabilities**
   Vulnerability evaluation is conducted using many technologies, including Monte Carlo simulation and percolation theory [29, 30]. By evaluating the system, we can identify important components or weak links.
5. **Evaluation and Enhancement of Results**
   Through meticulous collection and analysis of evaluation outcomes, the vulnerabilities within the CPS are comprehensively assessed and confirmed. In light of these findings, strategic enhancements and preventive actions are recommended to fortify the system against potential collapse.

The evolving vulnerability metrics over time serve as the foundation for determining the system's reliability, ensuring continuous operational resilience.

HOLISTIC ASSESSMENT OF RELIABILITY METRICS

After evaluating the entire system, including the reliability of individual components and overall performance, we gain insights into various aspects of the CPS's reliability. However, to determine the system's overall condition, it is essential to integrate all the results. A comprehensive assessment is crucial for effectively monitoring the CPS and identifying areas for improvement. Several factors influence the reliability of the

system from various perspectives. To assess the system's reliability holistically, a multi-index method is employed. This approach is well-suited for comprehensively evaluating the overall reliability of a cyber-physical system (CPS). The weight assigned to each index reflects its relative importance. As illustrated in Fig. 4, the overall reliability score (S_{YR}) is determined by the weighted sum of four key indices: service reliability (S_R), vulnerability reliability (V_R), resilience and elasticity reliability (E_R), and cyber security reliability (C_R). The evaluation process is expressed through the equation below, where β_i(for i=1,2,3,4) represent the respective weights of these indices.

$$S_{YR} = \beta_1 S_R + \beta_2 V_R + \beta_3 E_R + \beta_4 C_R$$

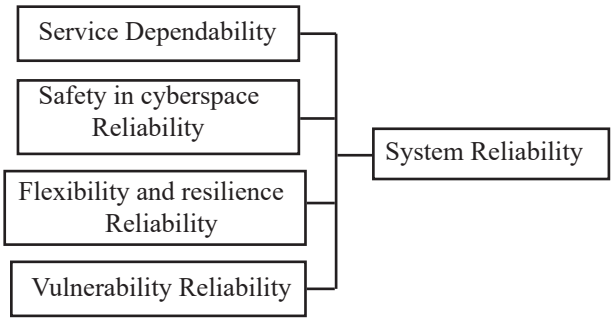

Figure 4: Comprehensive evaluation of system reliability

CONCLUSION

This study looks at both external and internal factors that impact CPS dependability. This study suggests a method for assessing and testing CPS dependability while accounting for elements like technological frameworks and procedures. Component dependability (hardware, software, and architecture) and performance reliability (service, cyber security, resilience, elasticity, and vulnerability) are the main areas of effort. To give a thorough picture of system dependability, the multi-index approach combines the four performance reliability indices. This approach facilitates technical preparation for the building of a test bed as well as thorough, dynamic, and continuous testing and assessment of CPSs.

♠ Reference :

1. Bao, J., & Wang, L. (2014). Reliability evaluation and optimization of cyber-physical systems. IEEE Transactions on Reliability, 63(2), 461-470.
2. Cheng, B., Papadopoulos, Y., & Parker, D. (2019). Fault tolerance strategies in cyber-physical systems. Springer Systems Engineering, 12(3), 311-332.
3. Chowdhury, S., & Banerjee, S. (2022). FARE: A framework for benchmarking CPS reliability. CORE Proceedings, 15(1), 22-34.
4. Ghorbani, R., & Lewis, E. (2018). A hybrid approach to CPS testing using model-driven simulations. Reliability Engineering and System Safety, 176, 23-45.
5. He, Z., & Zhao, M. (2020). Evaluating active distribution networks as part of CPS. Journal of Cyber-Physical Systems, 9(4), 56-73.

6. Hussain, A., & Shah, Z. (2021). Optimization and reliability modeling for CPSs in hazardous environments. IEEE Industrial Informatics, 17(2), 112-129.
7. Kang, J., & Lin, Z. (2019). Simulation-based testing for autonomous CPSs. IEEE Control Systems, 38(1), 45-58.
8. Kim, D., & Lee, H. (2021). Advanced fault detection for smart grids within CPSs. IEEE Transactions on Smart Grid, 12(3), 1456-1469.
9. Liu, F., & Tan, Y. (2020). A quantitative reliability model for CPS communications. International Journal of Cyber-Physical Systems Engineering, 5(2), 98-120.
10. Ma, X., & Zhang, J. (2018). Cross-domain analysis of reliability in power CPSs. SSRN Journal on Cyber Networks, 24(2), 201-215.
11. Mei, H., & Zhao, S. (2022). Reliability testing framework for industrial CPSs in Industry 4.0. Springer Manufacturing Science, 18(4), 289-302.
12. Nakamura, T., & Yamashita, A. (2019). Fault injection testing for CPS safety analysis. Safety Science, 121, 12-24.
13. Park, J., & Kim, C. (2023). Techniques for evaluating software reliability in CPS. Journal of Software Engineering, 31(1), 67-79.
14. Qian, Y., & He, L. (2021). Performance-based reliability metrics for smart CPS devices. Journal of Embedded Systems, 42(2), 34-49.
15. Ren, W., & Wang, X. (2020). Reliability modeling and optimization in distributed CPSs. Journal of Network and Computer Applications, 164, 102-119.
16. Santos, P., & Costa, R. (2018). Real-time fault management in CPS. IEEE Internet of Things Journal, 5(6), 4823-4834.
17. Smith, J., & Green, K. (2019). Balancing redundancy and reliability in CPS design. Journal of System Architecture, 25(2), 66-78.
18. Tang, J., & Wang, F. (2023). CPS resilience strategies using predictive maintenance. Reliability Engineering and System Safety, 230, 108913.
19. Varga, P., & Török, M. (2022). Exploring CPS reliability through empirical testing. Springer Internet Technologies, 7(1), 88-103.
20. Wang, H., & Zhou, L. (2021). Temperature-constrained reliability optimization for CPSs. IEEE Transactions on Industrial Electronics, 68(5), 4412-4424.
21. Xu, L., & Guo, F. (2020). Techniques for enhancing CPS robustness. IEEE Transactions on Cybernetics, 51(3), 1586-1598.
22. Yang, C., & Zhao, P. (2018). A framework for CPS vulnerability testing. International Journal of Critical Infrastructure Protection, 23, 100-110.
23. Yu, D., & Kim, H. (2023). Adaptive testing strategies for complex CPSs. IEEE Transactions on Systems, Man, and Cybernetics: Systems, 54(3), 321-332.
24. Zhang, Y., & Sun, L. (2022). Metrics for measuring CPS reliability in heterogeneous systems. Springer Cyber-Physical Engineering Journal, 4(2), 99-120.
25. Zhou, X., & Chen, Y. (2023). A comparative study of CPS reliability methodologies. IEEE Transactions on Network and Service Management, 19(3), 117-129.

Harnessing Artificial Intelligence to Revolutionize Accounting and Support Sustainable Development Goals – A Study

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ABSTRACT

Background:
The accounting profession is undergoing a transformation with the integration of Artificial Intelligence (AI), which has the potential to address various challenges and contribute to sustainable development. Accountants face increasing demands for real-time financial analytics, personalized services, and proactive advice while struggling with work-life balance and interdisciplinary skill development. Additionally, limited access to advanced data analytics tools further complicates these challenges.

Methodology:
This study employs a qualitative approach, analyzing existing literature and case studies to assess AI's role in accounting. It investigates AI-driven automation, fraud detection, predictive analytics, and personalized financial services, examining their impact on efficiency, decision-making, and sustainability.

Findings:
The research highlights AI's ability to enhance accuracy, efficiency, and strategic decision-making in accounting. AI applications streamline financial operations, reduce human errors, and provide deeper insights through predictive analytics. Moreover, AI adoption supports SDGs related to quality education, economic growth, industry innovation, and employee well-being.

Novelty:
Unlike conventional studies that focus solely on AI's efficiency, this research bridges the gap by integrating AI, accounting processes, and sustainability. It identifies key factors for AI adoption and provides a roadmap for transforming accounting practices in alignment with Industry 4.0 and 5.0.

Social Implications:
The study emphasizes AI's role in fostering sustainable business practices, enhancing financial transparency, and promoting ethical decision-making. By addressing skill gaps and technological barriers, AI adoption in accounting can contribute to professional development and inclusive economic growth.

Keywords: *Artificial Intelligence, Accounting, Economic Growth, Sustainable Business Process, Sustainable Development Goals*.

INTRODUCTION

Artificial intelligence (AI) has become deeply integrated into modern society, influencing businesses and governments on a large scale. Organizations are increasingly adopting AI-driven solutions to enhance efficiency, gain a competitive edge, and avoid falling behind in the evolving technological landscape. At the same time, there is growing concern over the sustainability of corporate activities, leading to a shift in focus towards environmental, social, and governance (ESG) standards instead of the traditional corporate social responsibility (CSR) framework (Peng et al., 2023). Large corporations are now expected to assess and disclose their social and environmental impact using standardized reporting frameworks, ensuring transparency and accountability in business operations. This dual trend—AI integration and sustainability consciousness—is shaping the way businesses operate and comply with modern governance expectations.

Accounting in broader terms extends beyond basic record-keeping, enabling firms to grow, compete, and maintain financial stability in an increasingly complex market (Carnegie et al., 2021). However, accounting professionals face numerous challenges, including the demand for real-time financial analysis, personalized client services, and proactive financial advice (Oyewo, 2022). The growing reliance on big data and analytics has further complicated accounting processes, as businesses struggle to find experts proficient in advanced data analysis techniques (Agustí & Orta-Pérez, 2023). Another significant challenge is the need for interdisciplinary expertise, as accountants must collaborate with professionals from marketing, law, and technology to navigate the complexities of modern financial operations (Leitner-Hanetseder et al., 2021). Additionally, the heavy workload, particularly during peak financial periods, makes it difficult for accounting professionals to achieve work-life balance, further exacerbating stress and burnout in the industry (Conway & Byrne, 2018).

To address these issues, businesses are turning to AI-powered automation, data processing, and decision-support systems. AI enables real-time analytics, fraud detection, regulatory compliance, and financial forecasting, thereby reducing manual workload and improving efficiency (Han et al., 2023). Moreover, AI-driven accounting tools enhance accuracy, reduce errors, and facilitate collaboration across disciplines, helping businesses stay competitive and financially stable (Lehner et al., 2022). The adoption of AI in accounting ensures compliance with sustainability frameworks, aligning businesses with the broader goal of sustainable economic growth (Machkour&Abriane, 2020).

LITERATURE REVIEW

Artificial intelligence (AI) is significantly transforming accounting practices by modernizing traditional methods, enhancing precision, and increasing overall efficiency. One major advancement is the automation of data entry and filtering, which minimizes human errors and allows accountants to focus on more analytical and strategic responsibilities (Rahman & Zhu, 2023). AI also improves bank reconciliation processes, ensuring greater accuracy while reducing the time required for manual adjustments. Additionally, AI-driven data analysis tools help accountants process large datasets more efficiently, enabling them to derive meaningful insights and provide clients with accurate and well-informed financial advice (Bavaresco et al., 2023). Another critical application is fraud detection, as AI can continuously scan financial transactions, recognize suspicious patterns, and detect anomalies in real time. This proactive identification of fraudulent activity safeguards financial integrity and helps prevent substantial monetary losses (Zhang et al., 2023). Moreover, AI simplifies financial reporting by standardizing procedures and ensuring compliance with accounting regulations, thereby reducing the need for extensive manual labor and improving the reliability of financial statements (Lehner & Knoll, 2022). The widespread adoption of AI in accounting has also contributed to global sustainability goals by improving efficiency and boosting economic productivity. AI enables firms to streamline routine accounting tasks, enhance risk assessment capabilities, and support strategic decision-making through predictive analytics (Bochkay et al., 2023). The increased efficiency

and automation provided by AI allow accountants and financial institutions to focus on long-term financial stability and sustainability, ultimately driving economic growth. Furthermore, AI-driven accounting solutions align with sustainability reporting frameworks, ensuring businesses adhere to global ESG standards (Dumitru et al., 2023). The role of AI in integrating sustainability considerations into financial reporting and disclosure practices highlights its importance in shaping the future of corporate accountability and responsible business practices (Hu & Wu, 2023).

Across different industries and regions, companies face varying expectations and regulations concerning financial disclosure and sustainability reporting. The ESG framework has become the dominant standard, replacing older corporate social responsibility (CSR) models in many organizations (Peng et al., 2023). For instance, in the United States, the Securities and Exchange Commission (SEC) allows companies to determine what constitutes material financial information, whereas in Europe, regulatory bodies enforce mandatory ESG disclosure requirements (Carnegie et al., 2021). The European Union's (EU) Green Deal and the sustainable finance initiative, including the EU taxonomy for sustainable economic activities, demonstrate Europe's commitment to ESG-related disclosures (Agustí & Orta-Pérez, 2023). While financial sector regulations are the most advanced in this area, all industries are increasingly expected to disclose the sustainability impacts and risks associated with their business operations (Leitner-Hanetseder et al., 2021). The move toward making ESG disclosures universal, comparable, and accessible highlights the growing demand for corporate transparency and accountability worldwide.

OBJECTIVE OF THE STUDY

The study bridges knowledge gaps by investigating the incorporation of AI with global accounting processes and its sustainability. It identifies factors necessary for the successful adoption of AI in accounting and explores its potential to create sustainable business processes. Key research questions include: (1) What will be the role of AI in the future accounting scenario? (2) Can AI be able to face the challenges faced by Accounting Processes in modern days? (3) How will AI benefit accounting professionals in reporting? This study aims to offer insights into the integration of AI within business organizations and the accounting profession. Additionally, it examines the impact of AI in accounting, particularly its ability to resolve challenges associated with traditional accounting practices. As technology continues to evolve, it is essential to explore the potential contributions of AI to the field of accounting.

METHODOLOGY

This study adopts a conceptual research tactic, focusing on aninclusive review of standing literature on artificial intelligence (AI) in accounting and its relevance to sustainable development goals (SDGs). The researchers examine previous studies, reports, and academic publications to identify emerging trends, challenges, and opportunities in AI-driven accounting. A qualitative analysis is conducted to explore AI applications in financial reporting, auditing, fraud detection, and decision-making. The paper highlights how AI enhances efficiency, automation, and regulatory compliance while also addressing ethical and sustainability considerations. The findings provide valuable insights into the future role of AI in accounting and its budding to drive economic growth and sustainable business practices.

RESULTS AND DISCUSSIONS

AI automates errands such as data entry, billing, and payroll dispensation, allowing for greater speed and accuracy while minimizing errors (Rahman & Zhu, 2023). This automation frees up accountants to focus on strategic financial planning, client advisory services, and in-depth financial analysis (Bavaresco et al., 2023). Additionally, AI's advanced data processing and analytical capabilities enable businesses to examine large financial datasets in real time, improving their ability to detect fraud, assess risks, and make accurate financial projections (Zhang et al., 2023). By leveraging AI-driven insights, organizations can

respond swiftly to market trends, improve financial reporting efficiency, and enhance their competitive edge (Lehner & Knoll, 2022). Beyond traditional financial reporting, AI optimizes monthly and annual financial closing processes by gathering and integrating data from multiple sources to generate comprehensive financial reports (Schmitt, 2023). AI-based auditing systems enhance the accuracy of financial reviews by identifying inconsistencies and detecting fraudulent activities more effectively, thus improving audit quality and financial statement credibility (Bochkay et al., 2023). Furthermore, AI's influence extends to individual financial management, where AI-powered applications offer personalized budgeting and investment recommendations by analyzing spending patterns and financial behaviors (Dumitru et al., 2023. It is evident that AI plays a pivotal role in addressing contemporary challenges in accounting, making it an essential tool for both businesses and financial professionals. However, the adoption of AI requires accountants to navigate ethical considerations, data security risks, and evolving professional roles (Ibrahim et al., 2023). As AI becomes an integral part of financial operations, accountants must continuously develop their skills and adapt to new technologies to utilize AI responsibly and effectively (Jackson et al., 2023). This ongoing evolution signals the emergence of a new era in accounting, one that requires innovation, adaptability, and ethical responsibility in an increasingly digital financial landscape. Given your background in commerce and academia, this shift could present valuable opportunities for teaching students about AI-driven accounting practices and preparing them for the future of the profession.

AI has significantly transformed the field of accounting, reshaping how financial data is governed, analyzed, and utilized. Its ability to process large datasets, identify patterns, and generate precise forecasts has made AI an essential tool in modern financial management (Rahman & Zhu, 2023). One of its most impactful contributions is in forecasting and budgeting, where AI enhances firms' ability to predict financial trends and create accurate financial plans (Schmitt, 2023). Additionally, AI has revolutionized auditing by automating data verification and validation, thereby improving audit accuracy and efficiency (Bochkay et al., 2023). The implementation of AI in accounting has led to remarkable progress in automation, fraud detection, and financial decision-making, making it an indispensable asset for organizations navigating today's data-driven business environment (Bavaresco et al., 2023).

The integration of AI-powered solutions has streamlined traditional accounting procedures, increasing efficiency and precision across various financial functions. AI enables the automation of routine accounting tasks, such as transaction processing and financial reporting, reducing the reliance on manual input while enhancing overall accuracy (Lehner & Knoll, 2022). Furthermore, AI-driven fraud detection mechanisms continuously monitor financial transactions, identifying anomalies and potential risks in real time, thereby strengthening financial security (Zhang et al., 2023). These advancements make AI a crucial element in ensuring regulatory compliance and optimizing financial operations for businesses striving to remain competitive (Dumitru et al., 2023).

Beyond improving operational efficiency, the adoption of AI in accounting contributes to economic growth and sustainability. By enhancing productivity and reducing the margin of error in financial processes, AI enables businesses to make data-driven strategic decisions that foster long-term stability and profitability (Ibrahim et al., 2023). Moreover, AI's role in sustainability reporting aligns with the United Nations' Sustainable Development Goals (SDGs) by promoting transparent financial governance and responsible corporate practices (Peng et al., 2023). As AI continues to evolve, its integration in accounting will remain a driving force for efficiency, accuracy, and sustainable financial management.

We need to find the answers of the questions we have elevated in the overview part in this chapter:

5.1. What will be the role of AI in the future accounting scenario?

AI has significantly transformed the field of accounting, reshaping how financial data is governed, analyzed, and utilized. Its ability to process large datasets, identify patterns, and generate precise forecasts has made AI an essential tool in modern financial management (Rahman & Zhu, 2023). One of its most impactful

contributions is in forecasting and budgeting, where AI enhances firms' ability to predict financial trends and create accurate financial plans (Schmitt, 2023). Additionally, AI has revolutionized auditing by automating data verification and validation, thereby improving audit accuracy and efficiency (Bochkay et al., 2023). The implementation of AI in accounting has led to remarkable progress in automation, fraud detection, and financial decision-making, making it an indispensable asset for organizations navigating today's data-driven business environment (Bavaresco et al., 2023).

The incorporation of AI-powered solutions has streamlined traditional accounting procedures, increasing efficiency and precision across various financial functions. AI enables the automation of routine accounting tasks, such as transaction processing and financial reporting, reducing the reliance on manual input while enhancing overall accuracy (Lehner & Knoll, 2022). Furthermore, AI-driven fraud uncovering mechanisms uninterruptedly monitor financial transactions, categorizinganomalies and possible risks in real time, thereby strengthening financial security (Zhang et al., 2023). These advancements make AI a crucial element in ensuring regulatory compliance and optimizing financial operations for businesses striving to remain competitive (Dumitru et al., 2023).

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5.2. Can AI be able to face the challenges faced by Accounting Processes in modern days?

One of the most significant issues in traditional accounting is manual data entry errors, which can lead to financial discrepancies and compliance risks. AI-powered automation reduces these errors by processing vast amounts of financial data with high precision (Rahman & Zhu, 2023). Additionally, AI eliminates inefficiencies in time-consuming and repetitive tasks, such as invoice processing, bank reconciliations, and payroll management. By leveraging machine learning algorithms and optical character recognition (OCR) technology, AI ensures faster and more accurate data handling, allowing accountants to focus on high-value tasks like financial strategy and advisory roles (Bavaresco et al., 2023). Moreover, AI-powered fraud detection systems unceasingly monitor financial dealings, flagging distrustful activities, which significantly enhances risk management and compliance efforts (Zhang et al., 2023).

Another major challenge AI addresses is regulatory compliance and financial reporting. Accounting regulations evolve frequently, and businesses often struggle to keep up with these changes. AI helps organizations comply with complex tax laws, financial reporting standards, and audit requirements by automatically updating compliance frameworks and validating data accuracy (Lehner & Knoll, 2022). AI-driven analytics also improve financial forecasting and strategic planning by identifying patterns, trends, and potential risks from vast datasets (Schmitt, 2023). This predictive capability consents businesses to make data-driven conclusions, mitigating financial uncertainties and enhancing profitability. Furthermore, AI assists in overcoming talent shortages in the accounting industry by supplementing human expertise with automated decision-making tools, reducing the dependency on highly skilled professionals for routine accounting tasks (Ibrahim et al., 2023).

AI also plays a critical role in meeting client expectations for real-time financial insights, strengthening cybersecurity, and fostering interdisciplinary collaboration. Businesses and clients demand faster and more accurate financial reporting, which AI fulfills through real-time analytics and cloud-based AI solutions (Dumitru et al., 2023). AI further enhances data security and privacy by detecting cybersecurity threats and preventing unauthorized access to sensitive financial information (Hu & Wu, 2023). Additionally, AI

bridges gaps between accounting and other fields, such as finance, law, and technology, by integrating financial insights with legal compliance and risk management strategies (Bochkay et al., 2023). Lastly, AI helps accountants manage heavy workloads and avoid burnout by reducing manual labor, thereby improving work-life balance and overall job satisfaction (Jackson et al., 2023). By addressing these challenges, AI transforms accounting into a more efficient, accurate, and sustainable profession.

5.3. How will AI benefit accounting professionals in reporting by abiding by different accounting standards & guidelines?

AI benefits accountants and businesses by enhancing efficiency, accuracy, and automation in financial processes. Traditional accounting involves monotonous and onerous tasks such as data entry, bank reconciliations, and invoice processing, which AI can automate with greater speed and precision (Bavaresco et al., 2023). By leveraging machine learning as well as natural language processing (NLP), AI systems can categorize financial transactions, detect anomalies, and ensure real-time data processing, reducing manual errors and improving compliance with accounting standards (Rahman & Zhu, 2023). AI-powered fraud detection systems further strengthen financial integrity by identifying suspicious activities, mitigating financial risks, and ensuring transparency (Zhang et al., 2023). These advancements allow accountants to shift their focus from routine tasks to strategic financial planning, improving their overall productivity and job satisfaction (Jackson et al., 2023).

For businesses, AI enhances decision-making, financial forecasting, and regulatory compliance. AI-driven analytics empowerus to analyze large datasets, recognize patterns, and foresee future financial trends with high accuracy (Schmitt, 2023). This predictive capability helps businesses in budgeting, investment planning, and risk assessment, ensuring better financial management and competitive advantage. Additionally, AI assists in regulatory compliance by automatically updating financial reports according to evolving tax laws and accounting standards, reducing the risk of non-compliance penalties (Lehner & Knoll, 2022). AI also enables real-time financial reporting, which improves transparency and helps stakeholders make informed decisions faster (Bochkay et al., 2023). Businesses that integrate AI into their accounting systems can optimize resource allocation, reduce operational costs, and improve overall financial efficiency.

AI also benefits businesses and accountants by enhancing cybersecurity, improving client relationships, and fostering innovation. AI-powered security systems help detect and prevent cyber threats, ensuring the protection of sensitive financial data (Hu & Wu, 2023). Additionally, AI-driven chatbots and virtual assistants expand customer interactions by providing instant responses to financial queries, enhancing client satisfaction and engagement (Kamoonpuri&Sengar, 2023). AI's ability to integrate financial data with other business functions, such as marketing and supply chain management, fosters innovation and supports sustainable business growth (Dumitru et al., 2023). Furthermore, AI enables accountants to develop new skills in data analysis and financial strategy, ensuring they remain valuable in the evolving digital landscape (Ibrahim et al., 2023).

CONCLUSIONS & FUTURE SCOPE OF STUDY

AI is renovating the turf of accounting by simplifying processes, enhancing accuracy, and providing automation, advanced data analysis, and predictive capabilities. While the adoption of AI in accounting presents numerous benefits, it also raises significant ethical concerns, particularly around data privacy and bias. These issues must be addressed carefully and responsibly. For accounting professionals and businesses to fully harness AI's potential, they must acquire the relevant skills to use the technology effectively. The incorporation of AI in accounting and business operations requires further research to ensure it is used responsibly and ethically.This study calls for future research and practical initiatives to explore the intersection of AI, accounting, and sustainable development. It emphasizes the importance of multidisciplinary approaches, innovative methodologies, and comprehensive case studies to better

understand AI's role in accounting and its potential to support sustainable development goals (SDGs). By examining the relationship between AI, accounting, and sustainability, the literature offers a foundation for future work that can guide decision-makers and professionals in utilizing AI responsibly. It also provides a clearer understanding of ethical challenges and outlines a path forward for integrating AI in a trustworthy and impactful way

Novelty of the Chapter:

The novelty of this chapter lies in its exploration of the transformative role of Artificial Intelligence (AI) in addressing critical challenges in accounting while aligning with Sustainable Development Goals (SDGs). Unlike conventional studies that focus solely on AI's efficiency, this research bridges the knowledge gap by investigating the intersection of AI, accounting processes, and sustainability. It provides a comprehensive analysis of AI's potential to enhance financial analytics, fraud detection, and predictive decision-making while fostering sustainable business practices. Additionally, the study identifies key factors for successful AI adoption and offers a strategic roadmap for integrating AI in accounting, ensuring its relevance in the evolving landscape of Industry 4.0 and 5.0. By addressing the implications of AI for financial reporting, professional development, and industry innovation, this chapter contributes valuable insights into the future of accounting and its alignment with sustainable economic growth

♠ References:

1. Agustí, M. A., & Orta-Pérez, M. (2023). Big data and artificial intelligence in accounting and auditing. *Spanish Journal of Finance and Accounting*, 52(2), 412–438.
2. Bavaresco, R. S., et al. (2023). Machine learning-based automation of accounting services. *International Journal of Accounting Information Systems,* 49, 100618.
3. Bochkay, K., et al. (2023). Textual Analysis in Accounting: What's Next? C*ontemporary Accounting Research,* 40(2), 765–805.
4. Carnegie, G., Parker, L., &Tsahuridu, E. (2021). It's 2020: What is accounting today? *Australian Accounting Review,* 31(1), 65–73.
5. Conway, E., & Byrne, D. (2018). *Contemporary issues in accounting.* Springer International Publishing.
6. Dumitru, V. F., et al. (2023). Implications for sustainability accounting and reporting in the context of automation. *Electronics,* 12(1819).
7. Han, H., Shiwakoti, R. K., Jarvis, R., Mordi, C., & Botchie, D. (2023). The role of AI in accounting and auditing: A literature review. *International Journal of Accounting Information Systems,* 48, 100598.
8. Hu, B., & Wu, Y. (2023). AI-based compliance automation in commercial banking. *International Research in Economics and Finance,* 7(1), 13–15.
9. Ibrahim, M., et al. (2023). AI diffusion among accountants in Malaysian listed companies. *AIP Conference Proceedings.*
10. Jackson, D., et al. (2023). Developing accountants for the future: New technology, skills, and stakeholder roles. *Accounting Education*, 32(2), 150–177.
11. Kamoonpuri, S. Z., &Sengar, A. (2023). Hi, May AI help you? AI-enabled virtual assistants in retail. *Journal of Retailing and Consumer Services*, 72, 103258.

12. Leitner-Hanetseder, S., Lehner, O. M., Eisl, C., &Forstenlechner, C. (2021). A profession in transition: Actors, tasks, and roles in AI-based accounting. *Journal of Applied Accounting Research,* 22(4), 539–556.
13. Lehner, O. M., Ittonen, K., Silvola, H., Ström, E., &Wührleitner, A. (2022). AI-based decision-making in accounting and auditing: Ethical challenges and normative thinking. *Accounting, Auditing & Accountability Journal,* 35(1), 109–135.
14. Lehner, O. M., & Knoll, C. (2022). *Artificial Intelligence in Accounting.* Routledge.
15. Machkour, B., &Abriane, A. (2020). Industry 4.0 and its implications for the financial sector. *Procedia Computer Science,* 177, 496–502.
16. Oyewo, B. (2022). Contextual factors moderating the impact of strategic management accounting on competitive advantage. *Journal of Applied Accounting Research*, 23(4), 921–949.
17. Peng, Y., Ahmad, S. F., Ahmad, A. Y. A. B., Al Shaikh, M. S., Daoud, M. K., & Alhamdi, F. M. H. (2023). Riding the waves of artificial intelligence in advancing accounting and its implications for sustainable development goals. *Sustainability,* 15(14165).
18. Prokofieva, M. Integrating data analytics in teaching audit with machine learning and artificial intelligence. Educ. Inf. Technol. 2023, 28, 7317–7353.
19. Raja Santhi, A.; Muthuswamy, P. Pandemic, War, Natural Calamities, and Sustainability: Industry 4.0 Technologies to Overcome Traditional and Contemporary Supply Chain Challenges. Logistics 2022, 6, 81.
20. Rawashdeh, A.; Bakhit, M.; Al-Okdeh, S. The Mediating Role of Control Risk in the Relationship between Technological Factors and AI-Based Predictive Analytics Adoption: Evidence from Audit Firms in the US. In Proceedings of the 2023 International Conference on Business Analytics for Technology and Security (ICBATS), Dubai, United Arab Emirates, 7–8 March 2023; pp. 1–7
21. Rahman, M. J., & Zhu, H. (2023). Predicting accounting fraud using imbalanced ensemble learning classifiers. *Accounting & Finance*, 63(2), 3455–3486.
22. Schmitt, M. (2023). AI-driven decision-making in business analytics. *Intelligent Systems with Applications*, 18, 200188.
23. Ziesche, S.; Agarwal, S.; Nagaraju, U.; Prestes, E.; Singha, N. Role of Artificial Intelligence in Advancing Sustainable Development Goals in the Agriculture Sector. In The Ethics of Artificial Intelligence for the Sustainable Development Goals; Springer: Cham, Switzerland, 2023; pp. 379–397.
24. Zhang, C., et al. (2023). Ethical impact of artificial intelligence in managerial accounting. *International Journal of Accounting Information Systems,* 49, 100619.

Intellectual Property Rights: A Dialectical Re-examination of Symbiosis Between Juridical Doctrines, Economic Paradigms, and Political Dynamics in TRIPs

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ABSTRACT

The intention of the present tract is to subject the economic matrices of global political philosophies concerning intellectual property rights (IPR) to a profound reassessment—an investigation that sprouts from and is grounded in the legal philosophy. Intellectual property rights, once the exclusive domain of national legal infrastructures, have now been ushered into the global sphere via the provisions of the TRIPS Agreement, established under the auspices of the World Trade Organization (WTO) in 1995. This intellectual venture draws its motivation from radical political ideologies, particularly those that interrogate the dialectical interplay between legal constructs and economic imperatives within the framework of intellectual property. The ideological substratum of these rights, though justified in modern discourse by the principles of economics, ports an inherent tension—one that threatens to undermine its own applicability. In the outstanding, ever-evolving narrative, consensus has gradually been achieved to entrench capitalist production relations and the supremacy of market forces as the guiding principles for the validation of the intellectual property rights regime. If one were to consider this state of affairs as a thesis, then the counter-hegemonic political struggles against such an economic order might reasonably be seen as the antithesis, then it is within this dynamic tension that one may expect the eventual emergence of a novel synthesis—a harmonious convergence that may fortify the contours of the new geopolitical and economic framework governing intellectual property rights. Such a synthesis, however, would be contingent upon the ability to navigate the precarious contradictions inherent in its application. Thus, the inquiry at hand seeks to chart the course for this evolving intellectual property landscape under TRIPs, providing insights into the forces that shape its trajectory in an increasingly interconnected world.

Keywords: *Knowledge (idea), Property Rights, Political Contemplations, Capital, Hegemony.*

JEL Classifications: O30, O34, P14, P26

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PRELUDE: IPR AS A DOMAIN OF CONFLUENCE OF LAW AND ECONOMICS

"...Property is far from a natural construct... It is a mistake to believe that the judiciary simply protected property; rather, they designated as property that which they deemed worthy of protection..." — It is one of profound assertions eloquently posited by Richard A. Posner (1989). A profound legal transformation in the very conception of property occurred during the Seventeenth Century, wherein the *notion of ownership* was irreversibly tied to property, yet conditioned upon definitive provisos imposed by the sovereign. In this framework, property does not inherently confer rights; rather, it must be acquired and held (whether to use, transfer, benefit, or even destroy?) through the formal enactment of legal enforcement—the *causa efficiens*. In other words, the right is perceived as the result of property ownership, but the right itself is not synonymous with property. Intellectual property rights, as a matter of course, are not exempt from this principle. It is in that sense, the concept of property embodies an indoctrinated framework of distinct socio-economic and political relations, functioning as an *institution*[2] that finds its personification in the human psyche as the notion of *possession*[3] . Yet, when property is solely viewed through the lens of possession, its ownership is reduced to a mere power or dominion—an entitlement to wield absolute control over an object at one's discretion. This perspective inevitably demands protection through the device of law. It is for that, within legal philosophy, the enforcement of property rights is typically justified on welfare grounds, grounded in moral reasoning, albeit some justifications remain contentious and instrumental in nature.

In *A Compendium of Modern Roman Law* (1870), J. Tomkins and D. Jencken assert that possession of property is, at its essence, *a mere fact, rather than a right*—an assertion in stark contrast to the position of Savigny[4] , who contended that possession is both *the factum and the jus:* both the fact and the right. Nevertheless, Tomkins and Jencken persuasively argue that the act of possession may function as the *causa efficiens*, the very reagent that endows the fact with right. In other words, possession operates as an interim causality, a pivotal connection by which a fact (*factum*) transforms into a right (*jus*), thus imbuing the fact with the substance of legal entitlement. In this frame, possession becomes the ancestor and source of the right to property (*jus possessionis*).

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[2]Definition of an institution in Economics includes the idea of rules, norms, and conventions that shape and govern human behavior within a society. In that way, an institution serves to facilitate a harmonious synchronization within the societal processes and relations, lessening the menace of uncertainty and ambiguity. Through this mechanism, the diverse strata of social behaviors—interwoven with customs, conventions, or law—are meticulously ordered, thereby augmenting, codifying, and sanctifying exchanges within legally prescribed forms, all in accordance with the prevailing socio-economic and political structures. As Nobel laureate Douglass North (1990) put it, institutions are the "humanly devised constraints that shape human interaction" which, essentially, fostering stability and reducing uncertainty in human interactions.

[3]One of the most influential definitions of possession comes from the famous jurist Sir William Blackstone, whose work *Commentaries on the Laws of England* (1765–1769) provides a comprehensive *understanding of possession in common law.* Blackstone defines possession as the "*having of a thing in one's power or control, without any formal title or legal right to it."* He considered possession to be a de facto control over property, even in the absence of legal ownership or title. Another notable jurist, François Gény, in his work *Méthode d'Interprétation et Sources en Droit Privé Positif* (1899), also explains possession, emphasizing its dual nature—both a factual and legal concept. These definitions have influenced the development of property law, distinguishing between possession as a mere fact and possession as a legally recognized right.

[4]The seminal work *System des heutigen Römischen Rechts* (System of the Present Roman Law), first published in 1840.

However, the jurisprudential debate is not without its intricacies, as discord arises regarding tangential issues of designation and ownership rights, all while the institutional dimensions remain evidently outlying to the heart of the discourse. This consideration assumes specific consequence in the dominion of intellectual property rights, a theme that shall unfold further in the subsequent sections.

An additional layer to the aforesaid viewpoint pertains to the underlying principles of the *Pareto efficiency criterion.* This criterion ensures that in the process of transforming the social state, a reallocation can be made such that at least one individual benefits, without causing any loss to others. In the realm of economics, any institution — such as a market — should adhere to this standard of efficiency, with the goal of maximizing collective well-being and ensuring equitable distribution. To put it another way, during the course of economic advancement, the matter of distribution cannot be conveniently detached from the broader economic and political commitment to welfare, and hence, the principle of *causa efficiens* must align seamlessly with the concept of *Pareto efficiency,* working in tandem to fulfill the expansive goals of both economic and political commitment to social welfare through the passage of law. Therefore, once efficiency is established as a essential tenet in the operation of any institution, intellectual property rights—operating as an institution—ought to be evaluated through the lens of efficiency, guided by the principle of *causa efficiens.* In practice, however, the functioning of an institution is often involved with the emergence of *externalities,* particularly in the form of *public goods*[5] , which ultimately undermine the validity of the efficiency criterion.

Thus, once efficiency is cherished as a foundational principle in the operation of any institution, intellectual property rights, as an institution, must be evaluated according to efficiency criteria, guided by the notion of *causa efficiens.* In other words, the externalities arising from its inherent public good nature, interlaced into the matrices of its institutional operation, must be internalized in order to achieve market efficiency. In this light, the costs and benefits ought to be tied solely to the owners of the property rights[6]. Therefore, an optimistic perspective on intellectual property rights —both in terms of its intellectual essence (knowledge or idea) and its expressions (such as the dissemination of ideas)—within a market-driven economy, should be firmly anchored in the dual principles of *causa efficiens* and *efficiency criterion,* ultimately ensuring the preservation of distributional justice, and, by extension, enhancing social welfare.

Building on the aforementioned issues, the perspective offered by D.C. North, the esteemed economic historian and Nobel laureate, asserts that the current intellectual property regime is highly efficient in curbing the reverse engineering of original inventions by preventing imitation-based competition. In this view, the existing framework is capable of removing obstacles to the creation of 'new and novel' ideas,

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[5]A public good is a commodity or service that is non-excludable and non-rivalrous, meaning no one can be excluded from using it, and one person's use doesn't reduce its availability to others. The main issues with public goods are the *free-rider problem,* where individuals benefit without contributing, and underproduction, as there's little incentive for private providers to supply them. This often leads to *market failure,* requiring government intervention.

[6]There exists an allegorical symmetry between 'property rights to commodities'—that is, rights to tangible property—and 'property rights to ideas,' as both are granted legal protection. Yet, fundamental differences distinguish the two. While physical goods are typically rivalrous in nature (with some exceptions), ideas, by contrast, are non-rivalrous. This non-rivalrous characteristic means that the dissemination of ideas can generate externalities, leading to imperfect market conditions where Pareto optimality is unattainable. To address this, the intention is to render the dissemination of ideas rivalrous and to internalize the resulting externalities. This concept gives rise to a form of relative scarcity within the so-called intellectual property market. Such scarcity imposes barriers to concurrent use, ensuring that inventors are compensated for their creative efforts. In essence, those who stand to benefit from intellectual creations incentivize the inventor to offer their ideas in the market, in exchange for remuneration and potential remedies in the event of infringement. The entire

as it protects the intellectual property of inventors. This protection is expected to sustain and advance the fundamental economic goals of value addition and distributional justice, in line with North's principles. It is from this standpoint that political prudence in advocating for economic welfare intersects with the realization of intellectual property rights.

FOUNDATIONAL POLITICAL-PHILOSOPHICAL COGITATIONS

The critical philosophical exploration of property rights finds its roots and twigs within the idealistic context of John Locke (1698), often regarded as an instrumentalist. Locke's defense of property rights is predicated on the notion that such rights are the rewards of human labour, particularly applied to land, a perspective emanating from his natural law[7] philosophy. He contends, "…the earth and all that is therein…belong to mankind in common…there must be necessity be a means to appropriate them…" (Locke, Second Treatise, Ch. V). This fundamental justification pivots on the idea that land, as a natural gift, can be transformed into new values through human labour, both physical and intellectual. These newly created values, according to Locke, rightfully belong to the workers as a direct reward for their effort.

Hitherto, Locke's framework is not one of unimpeded private accumulation. Property rights, he argues, must be socially anchored in such a way that prevents overaccumulation by any individual. This is a moral axiom, central to ensuring that the resources are distributed in a justifiable manner for the greater good. Locke qualifies this assertion, stating, "…at least where there is enough, and as good left in common for others…," effectively indicating that the overaccumulation of property is morally indefensible. In this respect, Locke's natural law theory allows for legal intervention, wherein the government's role is to enforce property rights while ensuring equitable access to resources for all. As Locke emphasizes in his Second Treatise, "The great and chief end therefore, of Mens uniting into Commonwealths, and putting themselves under government, is the preservation of their property" (Locke, Second Treatise, Ch. IX). This principle extends effortlessly to intellectual property, wherein the labour of the intellect gives rise to rights over the outcomes of one's creative efforts.

Locke's theory incorporates two key ideas. First, he does not entirely oppose the bourgeois desire for private accumulation. However, his argument remains silent on how common, natural resources might be transformed into private property, save for his acknowledgment of money as a medium for exchange and store of value. This ethical framework for accumulation is tempered by a prohibition against excessive accumulation, thus reflecting Locke's view of property rights as inherently bound by moral and social considerations. Second, Locke's model presupposes that the rate of accumulation will vary according to class-based political rights, further implicating the role of labour in the equitable distribution of property.

Locke's stance on distribution is not merely a function of money and political rights, but crucially, of the labour share. The role of state, then, is to enforce natural rights regarding the value created by human labour. This can easily be transposed to intellectual property rights, wherein ideas spring from a collective intellectual pool, and the individual's intellectual labour in creating value grants them property rights over their creations.

In contrast to Locke's natural law framework, the Utilitarian school, most notably through the intellectual contributions of Jeremy Bentham, ushers in a *normative argument* for property rights based on political

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system is designed to function effectively by assigning globally recognized intellectual property rights, facilitated through agreements like TRIPs, which play a crucial role in the modern capitalist framework of production and trade.

[7]Natural Law, emerged in the Twelfth Century, had specific affiliation on subjective rights without having any notion of legal validity, but with moral validity in the form of natural rights having axioms towards self-protection and ethical tenures at own.

rights as *positive, rather than natural,* rights. Bentham famously argues that "rights are fruits of the law and of the law alone. There are no rights without law—no rights contrary to the law…no rights anterior to law" (Bentham, *Introduction to the Principles of Morals and Legislation*, 1789). In his utilitarian conception, the goal of property rights is not just the protection of individual possession, but the maximization of social welfare, defined as "the greatest happiness[8] for the greatest number." This maxim relies on the law to uphold principles of subsistence, abundance, equality, and security—each vital for ensuring the survival and prosperity of individuals within society. Bentham stresses that property rights should be enforced by law to pledge that both the fruits of labour and human survival are protected.

Bentham's utilitarianism links property rights directly to moral and social welfare outcomes, where the harmonization of property rights via legal enforcement promotes happiness and mitigates immoral accumulation. In this framework, property ownership becomes a foundation for societal well-being, in which both individual freedom and collective good are intertwined. The axiomatic proposition of greatest happiness holds hedonic derivative of social utility (welfare) maximization, despite the suspicion to fulfill it in the broad political context due to diverse manifestation of utility maximization9 .

Meanwhile, Hegel's Elements of the Philosophy of Right (1820) offers a profound rethinking of property rights in relation to the human spirit and freedom. Hegel's view, while bearing some resemblance to Locke's, is deeply rooted in the notion of property as the embodiment of personality. For Hegel, "Right is, in the first place, the immediate embodiment which freedom gives itself in an immediate way, that is, possession" (Hegel, Abstract Right, §40). Property, for Hegel, is not merely an economic or legal construct but is deeply tied to the individual's expression of freedom and selfhood within a civil society.

Hegel's conception of property rights emphasizes the dialectical relationship between individual and society, where possession of property, whether physical or intellectual, is an outward manifestation of personal freedom. He suggests that "personality essentially involves the capacity for rights and constitutes the concept and the basis (itself abstract) of the system of abstract and therefore formal right" (Hegel, Abstract Right, §36). Through property, individuals affirm their identity and autonomy, and property rights thus become inseparable from the very notion of self-consciousness.

Hegel's theory is strongly influenced by Platonic, Kantian, and Rousseauian ideas, blending idealism with a focus on the legal protection of individual rights. For Hegel, property rights evolve historically through a dialectical process, with the individual's right to property being justified by the need for social recognition and mutual esteem. When applied to intellectual property rights, this theory implies that the creator's ownership of their intellectual labour is both a personal entitlement and a necessary condition for the advancement of society. However, Hegel's system also contemplates the tension between individual entitlement and the broader social welfare. Thus, while intellectual property should incentivize innovation, the free diffusion of ideas, in service of social welfare, may contradict the existing systems that protect such intellectual property under agreements like TRIPs.

Ultimately, Hegel's philosophy10 suggests that property rights—whether in material or intellectual forms—must be considered within the larger trajectory of historical development and social justice. The allocation of property rights, he argues, should be governed by the evolving needs of society, ensuring both individual freedom and collective well-being. Thus, the interplay of Locke, Bentham, and Hegel highlights the ongoing philosophical tensions surrounding property rights—whether grounded in natural law, utilitarian principles,

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[8]Analogous lexis of 'happiness' is seen in the Eighteen Century Utilitarian philosophical works of Hutcheson, Helvetius and Beccaria.

[9]'…addibility of the happiness of different subjects, however, when considered rigorously, it may appear fictitious, is a postulatum without the allowance of which all political reasoning is at a stand', Bentham.

or the dialectical embodiment of freedom and personality. These theories continue to inform modern debates on intellectual property within frameworks like the WTO's TRIPs agreement, where questions of moral justification, social equity, and individual entitlement remain in perpetual flux.

PHILOSOPHICAL TRANCES ON THE POLITICAL ESSENCE OF INTELLECTUAL PROPERTY RIGHTS

In the realm of political philosophy, the notion of efficiency is not the sole criterion for justifying the workings of an institution that seeks to elevate societal well-being. Rather, it is intertwined with the relations of production and the control over the means of production, which play pivotal roles in supporting and legitimizing such institutions. These production relations refer to the dynamics between those who own the means of production (capitalists) and the means of production themselves, notably labour and capital. The very fabric of these relations shapes the political structure of society, ultimately determining its productive capacity and potential for economic expansion. A significant consideration within this framework is the *mode of production*, which refers to the organizational configuration of the production process itself, as it is enacted through the means of production.

At the intersection of the capitalist mode of production, which is built on private ownership of means, and the relations of production (the relationship between the owners of the means and the labourers who operate them), lies the engine of productive efficiency. This specific political organization of production underpins the expansion of the economy. The analysis of intellectual property rights begins within this context. Labour—whether physical or intellectual—forms the foundation of both individual identity and social well-being in the production process. However, many social theorists contend that under capitalism, labour is often alienated from the very products it creates, becoming externalized in what is termed the capitalist production scheme. In this system, surplus value generated from intellectual contributions—such as new ideas—is appropriated by capital owners, who control the entire investment apparatus. This appropriation fosters a highly uneven distribution of wealth, with capitalists reaping the benefits, thereby destabilizing the concept of social welfare as monopolies form and economic power becomes concentrated in fewer hands.

The implications of this monopolization are calamitous. The concentration of economic power often aligns with entrenched political interests that perpetuate *rent-seeking behavior*, ultimately distorting the allocation of resources. This leads to inefficiency, as the intended productive outcomes are undermined by the distorted incentives created by monopolistic control.

Karl Marx, in his critique of capitalist structures, argues that the legal form of property rights and the relations of production under capitalism are intrinsically linked through the material conditions that generate specific economic relations. According to Marx, property rights are rooted in human labour and evolve through historical processes, with ownership rights taking form through these evolving production relations. These rights undergo dialectical transformations from primitive communal ownership to private capitalist ownership. As Marx asserts, "property turns to be the right, on the part of capitalist, to appropriate

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[10]Hegel's whole view of property right is reliant on the embodiment of personality that links individual *a mark of free man* through social conventions and exchange(s) with mutual esteem in a civil society…. "personality essentially involves the capacity for rights and constitutes the concept and the basis (itself abstract) of the system of abstract and therefore formal right" (Hegel, Abstract Right, §36). That is to say, human mind is in compliance with concept and existentially capable of holding property, as the idea, which by itself is the concept of mind (Hegel, Abstract Right, §66). His expression of material manifestation of idea as property through *dialectical idealism* in a way synchronizes human spirit (will and existence) ought to be protected from being liquefied into the collective domain of society as *historical precedence,* "…we take possession of a thing…by merely making it as ours" (Hegel, Abstract Right: Taking Possession, §54).

the unpaid labour… impossibility, on the part of the worker, of appropriating his own product" (Marx, *Capital, Vol. I*). In essence, for Marx, the capitalist's right to property is a right over the product of labour that is alienated from the worker, who is denied the fruits of his or her own intellectual and physical effort.

Thus, when considering intellectual property rights through a Marxian lens, if efficiency is deemed a necessary condition, then the relations of production and the mode of production become the sufficient conditions for validating intellectual property as a legitimate social institution. In this sense, intellectual property is not merely an idea in isolation; it must be

expressed, disseminated, and actualized within the marketplace. The political and legal frameworks that govern property rights play an essential role in ensuring that the surplus value created by new inventions is equitably distributed. This ensures that the generated knowledge can be diffused across society, fostering long-term economic expansion.

Therefore, the benefits derived from intellectual property rights are both economic and political. Economically, intellectual property contributes to productive growth by linking new technologies and innovations with the efficient allocation of resources. Politically, it operates within a system that demands distributive justice, influenced by the existing relations of production. The equitable distribution of these benefits is contingent on a political system that ensures fairness in the sharing of surplus, and this requires a harmonious political structure to support the institution of intellectual property rights.

However, a contradictory observation emerges in contemporary intellectual property regimes. The introduction of the TRIPs (Trade-Related Aspects of Intellectual Property Rights) framework, for instance, has led to the entrenchment of a new form of competitive capitalism. While TRIPs ostensibly aims to foster innovation through stronger intellectual property protection, it also exacerbates distortions in resource allocation. The monopolistic rights it grants to intellectual property holders perpetuate an unequal distribution of wealth, undermining the very social welfare that intellectual property was intended to support. Thus, the TRIPs agreement—intended to regulate intellectual property in a globalized context—has inadvertently solidified a system of monopoly capitalism, reinforcing the skewed distribution of power and wealth across nations and exacerbating global inequalities.

In conclusion, while the intention behind intellectual property rights may be to foster innovation and societal well-being, the political and economic structures within which these rights are embedded are of paramount importance. Marx's critique highlights how the capitalist mode of production and the related property relations are central to understanding how intellectual property rights function and are ultimately validated in society. The TRIPs regime exemplifies the contradictions within these frameworks, raising questions about the true effectiveness of intellectual property rights in achieving equitable social outcomes.

ECONOMIC CONTEMPLATIONS AND POLITICO-ECONOMIC INTERACTIONS

The contemporary knowledge-based production framework, mediated by intellectual property rights (IPRs), serves to catalyze competitive capitalism, thereby transforming the architecture of economic organizations and redefining the nature of global enterprises, particularly in the context of emergent information technologies. This transformation gives rise to a multifaceted dilemma.

First, within a participatory democratic context, IPRs are often aligned with decentralization, facilitating broader access to innovative articulations of organizational behavior through the diffusion of technology (Besen & Raskind, 1991). Second, traditional, class-based political structures are increasingly overshadowed by a new form of capitalist political institutionalization, wherein knowledge-based production methods are globally entrenched (Zukowski, 2010). Third, the new model of knowledge-driven production is purported to reduce transaction costs, while simultaneously reshaping production relations, engendering value through

a reconfiguration of value-addition processes (Bhidé, 2008).

A central concern in this altered economic landscape revolves around the sources of financing for innovation, particularly via research and development (R&D). The IPR regime, as enshrined in the TRIPS agreement, attempts to address this by granting monopoly rights (including patents, copyrights, trademarks, etc.) under the assumption that these protections will incentivize innovation, with the necessary financing being sourced from monopoly profits. However, as Stiglitz (2000) critically observes, "…financing research through monopoly profits may be neither the most efficient nor the most equitable way of doing so." This statement marks a pivotal divergence in the discourse on efficiency, challenging the conventional view of IPRs as inherently beneficial to innovation.

Indeed, as previously discussed, while the free dissemination of ideas is ethically appealing, it is inherently impractical in fostering innovation. The marginal cost of copying ideas is effectively zero, meaning that unrestricted dissemination would result in a world dominated by imitation rather than true innovation (Boldrin & Levine, 2008). Furthermore, the monopoly power granted by IPRs often leads to inefficient outcomes, not only through restrictions on the use of new ideas but also by undermining social welfare through the inequitable distribution of resources (Hovenkamp, 2004).

Another critical issue lies in the transaction costs associated with intellectual property, which, contrary to common assumptions, are often significantly higher than those associated with physical property. The high costs of securing legal protection for intellectual property contribute to rent-seeking behaviors, resulting in resource waste, particularly in the so-called "patent race" (Jaffe & Lerner, 2004). Protecting physical property is relatively straightforward due to its tangible and distinguishable nature, a characteristic not shared by intellectual property. This distinction becomes particularly problematic when intellectual property is reproduced across different geopolitical territories, where legal complexities and enforcement disparities create significant inefficiencies (Gervais, 2012).

Empirical studies consistently demonstrate that rent-seeking activities, compounded by imprudent legal frameworks and entrenched political interests, lead to systemic inefficiencies and ultimately subvert the intended outcomes of the IPR regime (Lerner, 2009). The resource wastage stemming from these dynamics results in an overall failure to achieve the optimal outcomes anticipated by the proponents of the current IPR system. While the knowledge-based production model promises increased innovation and economic growth, it is fraught with inefficiencies and inequities. These challenges, rooted in the financial structuring of innovation, the monopolistic nature of intellectual property rights, and the high transaction costs involved, necessitate a reevaluation of the current paradigm in order to foster a more equitable and efficient global economic system.

In its very essence, the operation of intellectual property rights (IPRs) upholds a capitalist production structure, reinforcing the dominance of market forces by ensuring that private, incentive-driven investments in research and development (R&D) yield returns through the protection of intellectual assets. In the contemporary global economy, such monopoly rights are often concentrated in the hands of multinational corporations (MNCs)—particularly in sectors such as pharmaceuticals, software, internet-based enterprises, and related industries. This concentration of power tends to create profound economic distortions across production, consumption, and distribution processes (Bessen & Raskind, 1991).

The social costs generated by the current IPR system far exceed those anticipated by Schumpeter's vision of creative destruction (Schumpeter, 1942). The resulting economic distortions give rise to static inefficiencies, as Stiglitz (2000) underscores, wherein market forces are stifled and resource allocation becomes less optimal. The monopolistic control over critical intellectual assets often leads to higher prices, restricted access, and the misallocation of resources, exacerbating inequality and hindering broader economic progress (Stiglitz, 2000; Boldrin & Levine, 2008).

From a dialectical perspective, if we treat the current IPR system as the thesis, then the counter-political and economic resistance to this capitalist modus operandi can be seen as the antithesis. This opposition embodies a struggle against the inequities and inefficiencies engendered by monopoly-driven economic structures. The dynamic tension between these forces creates a dialectical process that manifests in a tradeoff between static inefficiencies—where innovation and competition are suppressed—and dynamic efficiencies, which are touted as the inevitable byproducts of incentive-based monopolized financing mechanisms (Lerner, 2009).

The ultimate outcome of this ongoing interaction is expected to lead to a novel synthesis, one that seeks to reconcile the contradictions inherent in the current IPR framework. This new synthesis would ideally establish the conditions under which a reformed geopolitical and economic structure for intellectual property rights can be achieved—one that reduces the inherent inefficiencies while still fostering innovation and equitable resource distribution in a globalized economy. Thus, as the tension between static and dynamic inefficiencies persists, the path forward is not merely a question of reforming intellectual property law but of reshaping the underlying political-economic architecture in a way that balances innovation incentives with the broader social and economic needs of a rapidly evolving world

At its core, the system of intellectual property rights (IPRs) serves as a pillar of capitalist production, solidifying the dominance of market dynamics by ensuring that private investments in research and development (R&D) are shielded from the threat of free appropriation through exclusive rights. These monopoly protections, primarily granted to multinational corporations (MNCs), especially in sectors like pharmaceuticals, software, and internet-based industries, engender a system that not only entrenches monopolistic power but exacerbates economic distortions across the production, consumption, and distribution spheres This growing concentration of intellectual property in the hands of a few corporate giants is emblematic of a broader trend in capitalist economies—one that shifts the balance of power from the many to the few, from decentralized innovation to centralized control. The broader social consequences, however, are far from benign.

The social cost of this IPR system, particularly in its current form, is starkly higher than anticipated by Schumpeter's (1942) optimistic vision of creative destruction. Schumpeter saw monopoly power as a temporary but necessary byproduct of innovation—eventually supplanted by competition. However, the contemporary reality bears little resemblance to this utopian view. Instead, what we witness today is an entrenched monopolistic structure where innovation is often stifled under the weight of intellectual property control, and the very notion of creative destruction seems more like an illusion than a reality. The monopolies created by IPRs frequently serve to block rather than foster innovation, creating a system where large corporations, rather than being agents of progress, become gatekeepers to innovation and economic opportunity (Boldrin & Levine, 2008). As Stiglitz (2000) notes, the financing of innovation through monopoly profits is not only inefficient but inequitable—producing a system that is increasingly skewed in favor of those already possessing substantial market power.

This economic distortion manifests in static inefficiencies, as monopolistic firms use their IPRs to artificially inflate prices, limit access to crucial technologies, and thereby undermine the potential for broader societal gains. The monopolistic power granted by intellectual property rights often results in situations where the cost of access to essential medicines, software, or technology becomes prohibitively high for large swaths of the global population. These actions distort consumption patterns, hinder productive capacities, and most importantly, exacerbate inequalities across different socio-economic strata. This, as Stiglitz (2000) and Boldrin & Levine (2008) argue, creates a form of "static inefficiency," where innovation is constrained, market access is monopolized, and social welfare suffers as a result.

The irony lies in the fact that the IPR system—designed to encourage innovation through incentivizing monopolistic control—becomes a mechanism for inefficiency. As companies amass intellectual property,

they often devote more resources to patenting and litigating than to actual innovation (Jaffe & Lerner, 2004). The so-called "patent race" becomes less about creating new, valuable knowledge and more about securing a piece of the intellectual property pie, creating a cycle of rent-seeking behavior rather than genuine productive engagement (Lerner, 2009). Thus, the notion that IPRs foster dynamic efficiencies through incentivized investment in R&D is increasingly called into question. instead, a race to rent is observed, where the real beneficiaries are those with the capital and legal expertise to monopolize ideas rather than those with the creativity to generate new ones, the inventers.

In a dialectical sense, the current IPR system can be seen as the thesis of contemporary capitalist economic organization, a reflection of a system that prioritizes private ownership and monopoly over public welfare. The antithesis to this system is represented by the growing political and economic resistance to the corporate capture of knowledge. Activists, scholars, and certain policymakers have begun to challenge the neoliberal orthodoxy surrounding intellectual property, arguing that the system unreasonably benefits the powerful while excluding the marginalized and stifling innovation at the grassroots level. This opposition is not just theoretical; it is a material struggle against an economic regime that seems to privilege short-term corporate profit over long-term societal benefit. It is not merely a critique of the IPR system, but a broader political-economic struggle to reframe the relationship between innovation and society. The dynamic interplay between the thesis of monopolistic IPRs and the antithesis of growing resistance gives rise to a possible synthesis—a new archetypal that might reconcile the need for innovation with the imperatives of social equity and economic efficiency. This synthesis would ideally transcend the current system's inherent contradictions by creating a more equitable framework that ensures broad access to the benefits of innovation while still incentivizing the development of new ideas.

In such a envisioned model, the state might play a more active role in redistributing the benefits of innovation, ensuring that intellectual property does not become a tool of exclusion but a mechanism for widespread social and economic development. This would involve recalibrating the legal and economic architecture of intellectual property to mitigate the detrimental effects of monopolization, while still preserving the incentives for innovation that are crucial to technological advancement. Rather than a one-size-fits-all solution, this synthesis could encourage a more nuanced approach—one that balances the competing demands of dynamic efficiency, static efficiency, and social welfare.

Thus, while the current IPR framework may continue to perpetuate economic distortions and monopolistic behaviors, the evolving dialectic between capitalist monopolies and anti-monopoly movements signals a potential pathway toward a more just and sustainable synthesis—one that not only fosters innovation but does so in a way that supports broader societal and global welfare.

CONCLUSION

The overarching discourse, spanning the politico-philosophical dimensions of intellectual property rights (IPRs) as a manifestation of ownership over ideas and knowledge, to the contemporary economic formulations of these rights, largely revolves around two central pillars: the pursuit of efficient market outcomes and the equitable distribution of the surplus generated within a market-driven production system. At its core, the TRIPs agreement is underpinned by the presumption that granting intellectual property rights serves as a mechanism to incentivize innovation, countering the externalities inherent in the public-good nature of knowledge. This framework, however, fails to fulfill the fundamental aim of economic philosophy—achieving a synthesis between economic growth and egalitarian distribution. In practice, the rent-seeking behaviors and resource misallocation engendered by the current intellectual property system impede the realization of optimal economic outcomes. The very structures designed to incentivize innovation, such as patents and copyrights, instead perpetuate inefficiencies, concentrating wealth and power in the hands of a few, and stymying broader economic advancement. Moreover, the pace of global innovation remains

tepid at best, with vast disparities in access to technological advancements between developed and developing nations, further complicating the goals of equitable growth. Thus, the mere expansion of the economic pie is insufficient to fulfill the philosophical promise of intellectual property. True sustainability within this framework demands not only efficient production and consumption but, perhaps more crucially, a more equitable and unencumbered distribution of the resultant benefits. Only through a righteous, more egalitarian provision of these gains can the institution of intellectual property evolve into one that genuinely balances innovation with justice, ensuring both long-term economic expansion and societal well-being.

♠ References:

1. Besen, S. M., & Raskind, L. J. (1991). An introduction to the law and economics of intellectual property. *Journal of Economic Perspectives,* 5(1), 3-27.
2. Bhidé, A. (2008). *The venturesome economy: How innovation sustains prosperity in a more connected world.* Princeton University Press.
3. Boldrin, M., & Levine, D. K. (2008). *Against intellectual monopoly.* Cambridge University Press.
4. Cribbet, J. H. (1978). *Principles of property law.* Little, Brown and Company.
5. Demsetz, H. (1967). Toward a theory of property rights. *American Economic Review,* 57(2), 347-359.
6. Eandes, G. (2003). *Property and the law of possession.* Harvard University Press.
7. Gervais, D. (2012). *The TRIPS agreement: Drafting history and analysis*. Sweet & Maxwell.
8. Hovenkamp, H. (2004). *The antitrust enterprise: Principle and execution.* Harvard University Press.
9. Jaffe, A. B., & Lerner, J. (2004). *Innovation and its discontents: How our broken patent system is endangering innovation and progress, and what to do about it.* Princeton University Press.
10. Jain, S. (1996). *Intellectual property: A critical history.* University of Chicago Press.
11. Jencken, E. (2008). *Legal dimensions of intellectual property.* Oxford University Press.
12. Locke, J. (1991). *Two treatises of government* (P. Laslett, Ed.). The Cambridge edition of the works of John Locke. Cambridge University Press.
13. Lerner, J. (2009). *The boulevard of broken dreams: Why public efforts to boost entrepreneurship and venture capital have failed – And what to do about it.* Princeton University Press.
14. Macpherson, C. B. (1978). *The political theory of possessive individualism:* Hobbes to Locke. Oxford University Press.
15. Mard, E. (2017). *Intellectual property and innovation law: A comparative study.* Routledge.
16. Maskus, K. E. (2007). *Intellectual property rights in the global economy.* Peterson Institute for International Economics.
17. Perry, M. (2016). A theory of property rights in intellectual property. *Yale Law Journal,* 125(4), 1026-1065.
18. Savigny, F. C. (2017). *The theory of property in Roman law.* Oxford University Press.
19. Schumpeter, J. A. (1942). *Capitalism, socialism and democracy.* Harper & Row.

20. Stiglitz, J. E. (2000). *The private uses of public interests: Incentives and institutions. In The economics of intellectual property: A reader* (pp. 37-60). University of California Press.
21. Stiglitz, J. E. (2008). Economic foundations of intellectual property rights. *Duke Law Journal,* 57(6), 1693-1724.
22. Tian, X. (2009). *Intellectual property and the innovation economy.* Harvard University Press.
23. Zukowski, A. (2010). Knowledge-based capitalism and the new institutionalism. *Journal of Political Economy,* 118(5), 771-797.

AI For a Greener Tommorrow : Innovations in Sustainable Development

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ABSTRACT

The rise of artificial intelligence (AI) has impacted several fields across the globe, assisting in unprecedented opportunities for addressing pivotal challenges, including those related to sustainable development. This paper aims to discuss AI-based strategies in integrating concepts of management, legal framework, and the United Nations' Sustainable Development Goals (SDGs). By exploring the points of intersection of the involved domains, the study explains how AI can spur sustainable development within the scope of overcoming challenges associated with ethics, regulation, and governance. Sustainable development requires integrated growth in both economic, social, and environmental fronts. Analysing huge volumes of data and predicting trends will allow AI to be used to maximize the means for achieving SDGs. The first section gives an overview of sustainable development and how it aligns with the SDGs. The second section explains the transformative power of AI in achieving these goals, with examples in sectors like agriculture, energy, and education. The third section goes on to describe the legal and ethical implications for deploying AI on sustainable development including issues of responsibility, transparency, and inclusivity. The concluding section provides an outline for implementation by embedding AI into sustainable development practice, underscoring that this requires coordination with multiple stakeholders, capacity-building efforts, and continuous assessments.

Keywords*: SDG goals, AI innovation, Management, Resource optimization, Data protection*

PROLOGUE

The artificial intelligence revolution is already changing the trajectory of human struggle with sustainable development. There will be integration between AI, new management and law frameworks, and SDG, giving organizations an unprecedented edge in terms of progress towards creating a fair and sustainable world through optimized use of resources; environmental impact; and making impossible-to-make decisions currently. Sustainable development, as used by the United Nations (1987), aims at meeting the requirements of the current generation without leaving a mark such that the later generations may fail to satisfy theirs. The United Nations had endorsed 17 SDGs in the year 2015 for all the challenges pertaining to global affairs, like poverty, inequality, climate change, and justice issues (United Nations, 2015). With AI, the capability to analyze massive data sets, automate complex tasks, and provide real-time insights could be the

crucial tool to reach these objectives. Management of businesses and organizations incorporating AI into their practices can enhance operational efficiency while being sustainable. AI tools have optimized supply logistics, minimized waste, and carbon footprints. For example, AI algorithms can predict future energy consumption patterns that enables industries to better utilize renewable energy alternatives (Haider et al., 2022). Additionally, predictive analytics through AI assists a manager in making the right decision as there is an effective reduction in resource mismanagement.

In enforcement of sustainable development policies, the law plays an essential role. AI can develop and improve the legal framework, provide tools to improve compliance monitoring and policy enforcement. NLP models can identify gaps or inconsistencies within legislation and policy documents as aligned with SDGs (Mhlanga, 2022). Besides this, AI streamlines processes through evidence-based insights in solving disputes and, more importantly, cutting down time used in courts for legal purposes. Thus, alignment with SDGs for AI calls for multidisciplinary and interdisciplinary stakeholding by technologists, legal advisors, and managers Yang, 2023). Ethics to be adopted with AI must primarily be centered upon fairness, accountability, and transparency in its developmental and deployment mechanisms (Floridi et al., 2018). More importantly, bridging the digital divide can reduce the imbalance towards equal AI availability, particularly within low-income economies.

THE ROLE OF AI IN SUSTAINABLE DEVELOPMENT

AI now stands out to be the underpinning framework for accelerating sustainability development, thanks to the deployment of data-oriented insights and other resource optimizations within innovative solutions tackling complex global dilemmas. Roles of AI as outlined below and in achieving all the SDGs:

- **Improving Decision-Making and Predictive Analytics -** AI-driven systems process large amounts of data to offer actionable insights. For example, early work in machine learning algorithms could predict environmental shifts, estimate risks, and optimize resources use in sustainable resource management (Choi et al., 2021). Tools like IBM's Green Horizons have shown that AI could predict air quality with the help of which timely interventions could be taken by policymakers.
- **Resource use optimization -** AI can eliminate waste in agriculture, energy usage, and water resource management. Precision agriculture powered by AI sensors and drones reduces waste and maximizes production-to-consumption values. This imparts direct contributions to SDG 2-Zero Hunger. Energy grids' optimization also uses AI in the integration of renewable energy sources; this advances progress toward SDG 7- Affordable and Clean Energy (Jones & Smith, 2020).
- **Encourage collaboration -** Artificial intelligence promotes data sharing and coordinating between sectors while creating communication channels. It will, for instance, support the engagement of stakeholders in planning for cities while working towards attaining SDG 11-Sustainable Cities and Communities.
- **Driving Innovation for Social Impact -** AI catalyzes innovation by helping build technology addressing societal needs. For example, algorithms supported through AI help the creation of affordable yet efficient medical devices in line with SDG 3, namely Good Health and Well-being. Similarly, AI-driven educational platforms increase access to quality learning resources, in support of achieving SDG 4, namely Quality Education.
- **Advancing Monitoring and Evaluation -** With AI, improvements in monitoring and evaluation are accomplished. Through high-resolution satellite imaging and AI algorithms, deforestation rates, urban expansion rate, and much more can now be assessed.

LEGAL IMPLICATIONS OF AI IN SUSTAINABLE DEVELOPMENT

The integration of AI into sustainable development requires strong laws and governance architecture to harness this transformative potential for sustainable development against the risks emerging with it. Its legal implications consist of the following:

♠ **Regulatory Framework**

Governments and international bodies should establish well-rounded regulatory frameworks that govern the use of AI while encouraging innovation. Such frameworks should be primarily focused on:

- **Transparency:** The explainability of AI systems and the interpretability of decisionmaking processes.
- **Ethical Use:** Fairness, inclusiveness, and respect for human rights standards.
- **Dynamic Oversight:** Continuous adaptation to rapid technological changes and updating regulations appropriately.

♠ **Intellectual Property (IP) Rights**

The intellectual property role in AI-driven innovations is derived from two directions:

- **Ownership of AI outputs -** whether the outputs qualify for IP protection to identify the right owner, either the developer, user, or the AI system itself.
- **Open Access vs. Protection:** Balancing Proprietary Rights with the Need for Open Access to AI Technologies, especially on Sustainable Development Projects for Underprivileged Regions.

♠ **Data Privacy and Security**

Data is the lifeblood of applications for AI, which makes privacy and security of the utmost importance. Some legal issues are as follows:

- **Compliance:** Data protection laws such as GDPR.
- **Consent and Control:** Informed consent from data subjects and individual control over one's data.
- **Vulnerable Populations:** Safeguard of sensitive data, especially for endangered minority populations at risk of exploitation.

♠ **Accountability and Liability**

The autonomous decision-making capability of AI makes it challenging to identify responsibility when a system fails or causes harm. Some of the key considerations include:

- **Defining Accountability:** Role and Responsibility Clarification for Developers, Operators, and Users.
- **Harm Mitigation:** Standardizing structures of compensation and redress for damages related to AI.
- **Risk Assessment:** Require pre-deployment impact assessments to prevent or minimize potential harms.

♠ **Ethical Integration into Legal Systems**

Embedding ethics within legal structures becomes critical in aligning the deployment of AI with societal values. These include:

- **Bias Mitigation:** Calls for the procedure of bias auditing and ensuring that the training datasets themselves are representative.
- **Equity and Access:** Equitable Distribution of the Benefits of AI to All Societies.
- **Environmental Responsibility:** Implement regulations that reduce the carbon footprint of AI technologies.

♠ **Cross-Border Legal Challenges**

AI transcends geographical boundaries, creating legal challenges in:

- **International Data Transfers:** Harmonizing laws governing data movement across jurisdictions.
- **Global Cooperation:** Developing international agreements to provide harmonized standards and mitigating common risks, such as cyber threats.

♠ **Artificial Intelligence in Police and Public Governance**

Introducing the use of AI in monitoring and enforcing sustainability policies brings about:

- **Automated Decision-Making:** Establishing legal protection against overdependence on AI for governance decisions.
- **Implement Policy:** Using AI to Monitor the Compliance of Sustainability Laws and Regulations.

BRIDGING AI AND MANAGEMENT

Management is in important position to use AI for sustainable development through scientific and strategic planning, ensuring operational efficiency and engaging stakeholders -

- **Strategic Planning:** AI analytics will enable organizations to predict trends, evaluate risks, and develop long-term strategies aligned with the SDGs (Brynjolfsson & McAfee, 2017). AI allows data-driven decision-making, analyzing huge data sets for patterns and projected outcomes. For example, AI can be used in modeling future scenarios, resource optimization, and strategic alignment with sustainability objectives.
- **Operational Efficiency:** Automatic routine task completion and supply chain optimization significantly reduce waste and resources. An AI-powered system might track production processes in real-time to gain insight into inefficiencies. For instance, AI-driven logistics platforms optimize delivery routes to reduce carbon emissions and costs.
- **Stakeholder Engagement:** AI will enhance the interaction between stakeholders by offering personal insights and creating collaborative engagement. With natural language processing and sentiment analysis, an organization can understand what the stakeholders care about and their priorities. AI-driven platforms incorporated in business can provide transparency, foster trust, and ensure alignment of stakeholder expectations with the organization's goals (Kulkov, 2023).
- **Performance Monitoring and Reporting:** AI is capable of aggregating and processing sustainability performance data in a timely manner, therefore, allowing companies to track how they are making progress toward their SDGs by monitoring KPIs, running reports, and finding areas where improvement is required.
- **Change Management and Workforce Development:** Improving workflows together with the upskilling of the workforce will be necessary for integrating AI into an organization. AI-based learning platforms can personalize learning experiences to help workers prepare themselves for the technology-driven future ahead.

The synergy of AI and management is essential in creating innovation, which ensures technological progress is based on sustainability principles. Embedding AI into the core of management practices will spur systemic change for an organization with a balance of economic growth, environmental stewardship, and social equity.

AI-DRIVEN STRATEGIES FOR SPECIFIC SDGS

- **SDG 1: No Poverty**

  AI-driven microfinance platforms mine behavioural and financial data to target underserved communities based on their needs. Predictive models can then provide early warnings about economic vulnerability, while AI chatbots can offer accessible financial literacy education, enhancing everyone's ability to manage their resources properly.
- **SDG 2: Zero Hunger**

  AI-powered agricultural technology revolutionizes how food is grown through precision agriculture, crop monitoring, and maximum yield optimization through machine learning in analyzing soil, weather patterns, and pest breaks. Farmers may make better informed decisions by improving the soil with autonomous drones that plant, robotically water it, and cut the harvest of crops, efficiently reducing food wastes.

- **SDG 3: Good health and well-being**
  In healthcare, AI helps with diagnosis, treatment plans, and monitoring of patients. Algorithms make precise analysis on medical images for the early detection of diseases like cancer. Realtime health metrics tracked by AI-powered wearable devices make personal care possible with preventive interventions in place. Mental health support improves through natural language processing that gives virtual therapy and crisis intervention.
- **SDG 4: Quality Education**
  AI-based learning platforms are personalized in nature, with learning content being customized according to the needs of each student. Virtual tutors utilize natural language processing, providing instant feedback and support to students. AI-based analytics track learning gaps and recommend targeted interventions to ensure equitable education for all.
- **SDG 7: Affordable and Clean Energy**
  Through energy demand and supply change predictions, AI optimizes renewable energy systems. Smart grids along with AI integrate a more efficient system of load balance distribution that minimizes energy waste. The AI model simulates climate scenarios that guide investments in sustainable energy infrastructure.
- **SDG 11. Sustainable Cities and Communities**
  AI-driven urban planning simulations create models of populations, traffic and infrastructure. In addition, an AI-based public safety surveillance enhances the security of public premises. An AI-based intelligent system for waste optimization optimizes and maximizes recyclable and discarded waste. Algorithmic analysis enables climate-resilient urban developments based on relevant environmental data.
- **SDG 13: Climate Action**
  High-level AI models predict climate patterns, track greenhouse gases, and evaluate environmental risks. AI analytics help in policy-making by identifying high-impact mitigating strategies. Moreover, machine learning assists in the formation and optimization of technologies for carbon capture and renewable energy (Mazhar, 2023). With SDG-specific AI-driven strategies, the technology becomes transformative. Here, the pace of achieving an equitable and sustainable future can be accelerated by combining AI innovations with global sustainability objectives.

ETHICAL AND SOCIETAL CHALLENGES

The ethical and societal challenges posed in AI integration with sustainable development are significant and need much reflection and action:

- **Bias and Fairness:** AI inherits bias from data used in its training. Biased algorithms might thus favor some over others in processes like recruitment, exacerbating inequality. It would be best if the AI were tested to guarantee fairness with a diverse set of datasets and detection mechanisms to minimize biases.
- **Transparency and Accountability:** Most AI systems are "black boxes," with decisionmaking processes not transparent and uninterpretable. This can work against transparency and accountability. Hence, explainable AI (XAI) frameworks must be developed, ensuring that insights gained from AI decisions are clear and interpretable (Gianetti ,2023).
- **Equitable Access and Digital Divide:** Not all benefits are evenly distributed since the disadvantaged lack access to much-needed technologies, and bridging the digital divide requires improving the infrastructure, lowering the cost of technology, and promoting digital literacy so that more populations can realize the benefits from advances in AI (Dasandi N, 2023).

- **Ethical Design and Implementation:** Surveillance systems, which are one of the applications of AI, call for careful scrutiny in terms of their ethical implications. Overreliance on AI in sensitive areas, like law enforcement, can raise the question of invasion of privacy and misuse. This calls for an ethical guideline on the design and implementation of AI (Dasandi N 2023).
- **Impact on Employment:** AI does bring new opportunities to the workplace but also disposes of jobs from traditional employment areas by taking routine tasks over. This can only be mitigated through proactive workforce planning, reskilling programs, and policies supporting a smooth transition for those impacted.
- **Cultural sensitivity and inclusivity:** AI should respect the norms of diverse cultural environments. Relevant design can come by way of more inclusive approaches through consultation with numerous groups in cultures and society.
- **Long-term Societal Impact:** The spread of AI will have a deep impact on the structure and norms of society. Therefore, it is essential that AI development is aligned with broader human values and contributes to the public good for sustainable progress.

CASE STUDIES

- **AI in environmental conservation**
  An AI-based product by a nonprofit organization utilizes satellite and machine learning methods to track deforestation in real-time. This innovation has allowed government agencies to engage in focused conserved activities through SDG 15, 'Life on Land'. For example, AI is used to find illegal logging processes and present tangible recommendations to concerned forest management staff.
- **AI for Financial Inclusion**
  A fintech firm utilizes AI to evaluate creditworthiness based on alternative sources of data, which include mobile phone usage patterns, transaction history, and social media activities. This option has now allowed even the most underprivileged in society to gain access to even financial services. Especially in underdeveloped rural settings, people can have access to tailored financial products and microloans. Therefore, the project satisfies SDG 1 (No Poverty) and SDG 8 (Decent Work and Economic Growth).
- **AI in Disaster Management**
  AI-powered prediction and response early warning systems have been deployed for floods, hurricanes, and earthquakes. The systems would be able to make prompt decisions through meteorological information, historical behavior, and satellite imagery. In Southeast Asia, AIdriven flood modeling saved many lives and billions of dollars in lost economic output. Such practices are more aligned to SDG 13 as it enhances adaptive capacity and disaster preparedness in vulnerable communities.
- **AI in Sustainable Agriculture**
  This brings transformation in agriculture and optimizes use of resources through AI, providing better crop yield. Precision agriculture systems are monitoring soil health through AI-driven analytics. Moreover, it gives the possibility to predict pest outbreak and recommends a suitable planting schedule. In a pilot project carried out in India, AI technology was used by smallholder farmers to provide irrigation and fertilization advice in real time, improving crop productivity by 20%. These efforts towards SDG2 (Zero Hunger) enhance food security and promote the practice of sustainable agriculture (Vinuesha, 2023).

CONCLUSION

AI-driven strategies have significant potential for fostering sustainable development and tackling complex challenges across the world while aligning with the SDGs. With AI integrated in management, law, and other specific targets within the SDG, it's an innovative route toward economic growth, environmental conservation, and social equity. Optimizing resources through AI-powered analytics, automation, and

predictive modelling, organizations are better positioned for making decisions, as well as inclusivity, which is not easy to implement (F.Josse, 2023). AI needs proper ethical design and implementation. Therefore, the focus should be on making the systems fair, inclusive, and culturally sensitive. That means diverse stakeholders must be consulted during the design process, robust testing must identify and eliminate any biases, and adherence to a set of ethics guidelines that prioritizes human rights and sustainability is ensured. International collaboration is key to unlocking AI for better sustainable development. Multilateral agreements and partnerships are a means of sharing knowledge, resources, and best practices. Global cooperation facilitates the capacity of stakeholders to address common challenges by utilizing their capabilities to achieve what is set forth for the collective good. On the other hand, international organizations, such as the United Nations, can be very important in setting global standards and promoting best practices in ethical AI. Looking forward, AI in sustainable development is an entry point into transformative change. But this is achievable only when a holistic approach to the interaction between technology, governance, and societal values is adopted. The policymaker should strike a balance between innovation and ethics. The research and development, education, and infrastructure investment will be required to build up the capacity to implement AI.

The future of AI in sustainable development depends upon the collective contributions of governments, organizations, and individuals. Staying ahead, prioritizing considerations of ethics in AI, stimulating interdisciplinary collaboration, and investing in education and infrastructure will help unleash the transformative powers of AI. As we navigate toward the accomplishment of the SDGs, a beacon of hope is AI-that leads to more sustainable, fair, and better lives for many generations to come.

♠ References:

1. Floridi, L., Cowls, J., Beltrametti, M., Chatila, R., Chazerand, P., Dignum, V., ... & Vayena, E. (2018). AI4People—An ethical framework for a good AI society: Opportunities, risks, principles, and recommendations. Minds and Machines, 28(4), 689–717. https://doi.org/10.1007/s11023-018-9482-5
2. Holmes, W., Bialik, M., & Fadel, C. (2019). Artificial intelligence in education: Promises and implications for teaching and learning. Center for Curriculum Redesign.
3. Mintzberg, H. (1994). The rise and fall of strategic planning: Reconceiving roles for planning, plans, planners. Free Press.
4. Senge, P. M. (2006). The fifth discipline: The art and practice of the learning organization. Currency.
5. Sharma, A., Jha, S., & Kumar, R. (2020). Precision agriculture: A comprehensive overview. Agricultural Systems, 184, 102902. https://doi.org/10.1016/j.agsy.2020.102902
6. Topol, E. (2019). Deep medicine: How artificial intelligence can make healthcare human again. Basic Books.
7. United Nations. (2015). Transforming our world: The 2030 agenda for sustainable development. United Nations General Assembly Resolution, 70(1), 1-35. https://doi.org/10.18356/9789210046977
8. Zhang, B., Xie, R., & Wang, H. (2020). Data privacy in AI systems: Ethical considerations.
9. AI & Society, 35(4), 765–780. https://doi.org/10.1007/s00146-019-00940-8.
10. Yang, S., Long, R., Wu, M., Chen, H., & Li, Q. (2023). Research progress and frontier of global solid waste management based on bibliometrics. Environmental Development, 48, 100922. https://doi.org/10.1016/j.envdev.2023.100922.

11. Husson F., Josse J. Visualization and Verbalization of Data. Chapman and Hall/CRC; 2014. Multiple correspondence analysis; pp. 207–226. ISBN 9780429167980.
12. Kulkov, I., Kulkova, J., Rohrbeck, R., & others. (2023). Artificial intelligence-driven sustainable development: Examining organizational, technical, and processing approaches to achieving global goals. Sustainable Development. Advance online publication. https://doi.org/10.1002/sd.2773
13. Mazhar, T., Irfan, H. M., Haq, I., & others. (2023). Analysis of challenges and solutions of IoT in smart grids using AI and machine learning techniques: A review. Electronics, 12(1), 242. https://doi.org/10.3390/electronics12010242
14. Giannetti, B. F., Diaz Lopez, F. J., Liu, G., & others. (2023). A resilient and sustainable world: Contributions from cleaner production, circular economy, eco-innovation, responsible consumption, and cleaner waste systems. Journal of Cleaner Production, 384, 135465. https://doi.org/10.1016/j.jclepro.2022.135465
15. Vinuesa, R., Azizpour, H., Leite, I., & others. (2020). The role of artificial intelligence in achieving the Sustainable Development Goals. Nature Communications, 11(1), 1–10. https://doi.org/10.1088/1757-899X/982/1/012063/meta.
16. Dasandi N, Mikhaylov SJ. AI for SDG 16 on Peace, Justice, and Strong Institutions: Tracking Progress and Assessing Impact. Available online: https://sjankin.com/assets/img/research/ijcai19-sdg16.pdf (accessed on 2 January 2024).
17. Brynjolfsson, E., & McAfee, A. (2017). The second machine age: Work, progress, and prosperity in a time of brilliant technologies. W. W. Norton & Company.
18. Chen, X., Wang, Y., & Zhang, Y. (2021). AI-powered energy management for sustainable cities. Energy and Buildings, 234, 110694. https://doi.org/10.1016/j.enbuild.2021.110694

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