

AI IN CIRCULAR ECONOMY - THE LINKAGE BETWEEN SUSTAINABLE GROWTH AND DEVELOPMENT – AN INDIAN PERSPECTIVE

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ABSTRACT

The growth of industry and economy – in current times have been aided mostly by AI to a very great extent. AI goes to shape circular economy and the way we work across sectors and in organisations as well as our everyday lives. The circular economy which is technology dependent, leans heavily on AI for development of new tools, products and applications and enable us to realise greater value addition for the outlay incurred. The Circular economy and industry 4.0 are closely dependent on AI and enables us to go one step to sustainable development. AI here again helps us to tackle these challenges we face on the way. So it is not far off to state the scope of AI in circular economy is crucial in maintaining our growth, and to ensure its sustainability in future. AI in the Context of Circular Economy is more relevant now than earlier for economic development is thus going to be a key factor that can perhaps make our future more sustainable, economically viable protecting our resources with growth aspects. The current pandemic induced behaviour has further accentuated the need for moving the value chain of products and services into the digital mode and again it is AI which is expected to play a key role in the process. The authors have reviewed the existing body of literature in this regard and shares their perspectives on what could possibly be the way AI in circular economy would take in our journey to make the economic development more sustainable and beneficial to various sectors of industry and also for maintaining sustainable living possible. Developments in AI technologies, disruptive innovations are more likely to be arising in our Indian economy, and more particularly in the context of economic development, will act as a growth catalyst. The author also takes a look at the sectors where it is likely that products and services are going more into Circular economy, its implications for the consumers and society at large.

Key Words: AI, Sustainable growth, CE, Industry 4.0, Economic development, Recyclable technologies, Energy efficiency, material reduction, Cost reduction, Environment, Business models.

INTRODUCTION

The Role of Circular economy in today's economic development, with advent of AI in recent times have gone through a radical transformation especially in the type of

technologies, the applications and the sectors they are found to be a part of. As we move into the future, the Circular economy (CE) is going to face the impact of AI in both its variants – the benefits as well as the unmitigated ills which come along with the technology. It is therefore imperative for us as the users and developers of technology, the products, and the application as to how ready we are to face the challenge. While our inability to face the challenges will only be a set back to our efforts albeit temporarily, the positive side reflects an upside from a SDG perspective. CE with AI pervades all areas from water supply, energy management, waste management, efficiency improvement, effectiveness and value chain migration, general industrial output growth by a high factor. The new sectors where AI is likely to play in CE role is related to country-wise classrooms-low cost distributed education system, health care, logistics, food chain, space and defence, and construction of smart cities, waste management. CE with AI can be potent recipe for accelerated growth in the post pandemic, capital starved phase for large nation like ours and enable better value addition and outputs of goods and services, without taking heavy debt. It is here Technologists, sociologists, Govt and entrepreneurs alike are finding it difficult to cope up with shorter shelf life for technologies, tools, platforms, interfaces etc. which are getting continuously upgraded or replaced by new ones. The regenerative nature of circular economy will enhance our ability to cope up with the capital starved sectors and is likely to accelerate innovations in near future.

The recent pandemic had its implications in terms of affecting the business climate, the economic growth, credit available to the industrial units, consumption by households and imposed higher burden of health care costs on the society. These in turn all the more make it imperative for us to focus on effective use and adoption of AI technologies in CE for development of the various sectors and improve the effectiveness of use of resources at our disposal in a measured and fair manner in the future.

The author here proposes to examine past literature in this regard and the way the society and economy is going to be shaped up by increasing role played by AI in today's circular economy in day to day life, and its effect on sustainable growth. The likely impact of the same in the future, as well as the sectors that are likely to be affected are also outlined in brief.

REVIEW OF LITERATURE

AI use today in circular economy is so extensive that it has become catalyst for growth and economic development can perhaps be done in an effective manner only by recourse to use of technologies, which uses AI tools and applications extensively and has wide ramifications across industrial sectors and the general economic conditions, for societal growth. AI has thus become more focussed and the technologist has to closely work with development economists and sociologists for making it better for use and application to different tasks required by society. AI thus enables growth, sustainably using affordable technologies in a cost effective manner, with long term sustainability in view. An integrated approach to projects, executables is called for considering the rapid pace at

which AI is coming into our lives on a day to day basis. The author believes that certain sectors in circular economy like water, energy consumption, food chain, logistics, environment resource protection, effective waste management will heavily be utilising AI applications for solutions- and these will give the maximum pay off.

(1) Pagoropoulos, A., Pigosso, D. C., et al (2017), According to them, the Circular Economy is defined as an economy that is designed to be restorative and regenerative, and Multiple Product Service-Systems (PSS) have been developed as a result of digital technologies, with significant economic, environmental, and societal benefits. One of the most promising paradigms is the Circular Economy, which is motivated by business models and value propositions that have previously been developed in the PSS literature. This study used a review procedure to perform a systematic evaluation of the literature in order to assess the use of important digital technologies in the Circular Economy, and this study used a review procedure to perform a systematic evaluation of the literature in order to assess the use of important digital technologies in the Circular Economy.

(2) Rajput, S., & Singh, S. P. (2019), They investigate the hidden link between the Circular Economy (CE) and Industry 4.0 in the context of supply chain management in their research. The aspects that link CE to Industry 4.0 are looked at from two angles: enablers and restrictions. The study identifies twenty-six key enabling elements and fifteen key challenging factors, which are factored using Principal Component Analysis (PCA). The factors generated by PCA are analysed using the DEMATEL algorithm. The DEMATEL is a tool for analysing three sorts of data: optimistic, pessimistic, and most likely. According to the study, Artificial Intelligence, Service and Policy Framework, and Circular Economy were identified as important facilitators in merging CE with Industry 4.0. According to the report, the most significant barriers to connecting CE with Industry 4.0 in a supply chain are Interface Designing and Automated Synergy Model.

(3) Patwa, N., Sivarajah, U., Seetharaman, et al (2021), The Circular Economy (CE) and global adoption of its concepts are more important than ever before in order to maintain the rate of production of products and services in order to meet the ever-increasing consumer demand that is straining the environment and society, according to the study. The adoption of CE principles in emerging economies is examined since the difficulties they face in terms of resource availability, government policies, and consumer behaviour differ from those in industrialised ones. This paper provides an experimentally validated CE adoption model based on a sample of 183 customer responses. The study emphasises the significant impact of factors such as customer behaviour on the acceptability of remanufactured items and the use of products as a service on the acceptability of remanufactured items and the use of products as a service. This study provides information to businesses, consumers, and policymakers about steps implemented by emerging economies that are consistent with CE principles.

(4) Bag, S., Pretorius, J. H. C., Gupta, S. et al. (2021) declare that Artificial intelligence backed by big data analytics has grown in relevance in recent years. The literature implies that artificial intelligence fueled by big data analytics can improve supply chain performance, but there has been little research into why firms utilise artificial intelligence powered by big data analytics. They looked at how automotive businesses organise actual resources and worker skills to advance technology enablement, improve sustainable manufacturing processes, and build circular economy capabilities, using institutional theory and resource-based perspective theory. To evaluate the research hypothesis, they used primary data from 219 automotive and allied manufacturing businesses in South Africa. They statistically validated the theoretical framework, which explains how institutional pressures on resources affect the adoption of big data analytics-powered artificial intelligence, as well as how this affects sustainable manufacturing and circular economy capabilities, while accounting for the moderating effects of organisational flexibility and industry dynamism.

(5) Bag, S., & Pretorius, J. H. C. (2020), As a result of the digital revolution, manufacturing organisations confront several challenges and opportunities. The impact of Industry 4.0 on sustainable manufacturing and the circular economy has gotten little press. Their paper assesses the most recent research in the fields of Industry 4.0, sustainable manufacturing, and the circular economy, as well as build a research framework that will show critical pathways, adding to the body of knowledge by providing a thorough examination of Industry 4.0, sustainable manufacturing, and the circular economy, as well as proposing a research methodology that incorporates these three modern concepts into supply chain management. Based on their analysis of this integrated research framework, the authors propose a future study agenda and seven research propositions. For factory workers and the surrounding community, the conventional production process has a number of negative implications. The condition of the environment is degrading to the point where pollution from industry operations is affecting individuals living hundreds of kilometres away. As a result, sustainable manufacturing is manufacturers' only option for assisting in the transition to a circular economy, and this approach can help businesses improve their circular economy skills.

(6) Awan, U., Sroufe, R., & Shahbaz, M. (2021) It's worth noting that study into the Fourth Industrial Revolution (Industry 4.0) and the circular economy has risen in popularity since 2014. In the development of the project, the circular economy, which is increasing at the same time as the internet of things (IoT), presents both risks and opportunities to various stakeholders. The purpose of this literature review is to learn more about Industry 4.0. Desires and expectations of stakeholders on how the Internet of Things can help with circular economy management Among the contributions is the identification of many IoT technologies for addressing the challenges of the circular economy while also addressing best practises for implementation. A better knowledge of

the circular economy is essential for Industry 4.0. Understanding of the government, suppliers, and foreign organisations' interests, as well as There are a lot of expectations when it comes to the Internet of Things. This study opens the stage for future circular economy research.techniques, as well as the long-term potential for manufacturing enterprises to benefit from them. This study's findings should help practitioners and researchers better understand the literature and critical aspects of the transition to a more circular economy.

(7) Kristoffersen, E., Blomsma, F., Mikalef, P., & Li, J. (2020),DTs such as the Internet of Things (IoT), big data, and data analytics are mentioned as essential enablers of the circular economy (CE). Due to the fact that CE and DTs are both new domains, there is little systematic guidance on how to use DTs to fully realise the promise of circular strategies for resource efficiency and productivity. They conducted a theory-and-practice review that resulted in the Smart CE framework, which aids in the translation of circular strategies, which are central to manufacturing companies' goals in contributing to the UN's 12th Sustainable Development Goal, "sustainable consumption and production," into the BA requirements of DTs. The framework could help academics and practitioners (1) create a common language for aligning activities across disciplines like information systems and the CE body of knowledge, and (2) identify the gap between current and entailed BA requirements, as well as the strategic initiatives needed to close it. Their methodology is also being utilised to organise a database of case studies in order to find some best practises for certain smart circular strategies.

(8) Fogarassy, C., & Finger, D. (2020) state that circular solutions are required to solve the future concerns of depleting resources and escalating environmental problems. Regional contexts influence the complicated nature of material and energy systems, as well as fluctuating economic and technical situations, resulting in a wide range of results in developed and rapidly emerging countries around the world. Circular product planning, zero waste management, service-based repairing, refurbishing, and remanufacturing, to name a few of the theoretical ways they offer for assisting the transition from linear to circular resource utilisation, are just a few of the theoretical approaches they recommend. Theoretical models can be used to present and assess circular solutions in order to guarantee and ensure a successful implementation. The application of novel technology approaches, business solutions, and organisational development can all be aided by theoretical models and new scientific findings that promote innovation processes, and their article focuses on innovative and sustainable ways to aid and permit proper resource usage and recovery.

(9) Dantas, T. E., De-Souza, E. D., et al (2021) According to them, the 17 Sustainable Development Goals (SDGs) are interconnected strategies to promote sustainable practises and solutions that address the most pressing problems facing our society, while

two new topics, Circular Economy (CE) and Industry 4.0, are currently of interest as they may implement systematic changes and contribute to the achievement of the SDGs. A systematic literature study was conducted to evaluate how the CEI4.0 Nexus, a mix of CE practises and I4.0 technology, can aid in the achievement of the SDGs, with a focus on the sustainability of the CEI4.0 Nexus. SDG 7, SDG 8, SDG 9, SDG 11, SDG 12, and SDG 13 all benefit directly from CEI 4.0 Nexus, according to their findings. The joint efforts are aimed at achieving specific objectives. SDG 7, SDG 8, SDG 9, SDG 11, SDG 12, and SDG 13 all benefit directly from CEI 4.0 Nexus, according to their findings. The specific aims that can be achieved by combining CE practises and I4.0 technology are highlighted. The CEI4.0 Nexus is critical for achieving the SDGs because it blends breakthrough technology with new cycle production and business models, offering a chance to address the SDG goals highlighted in this report.

Various studies that have been conducted in the past have already established the importance, relevance and linkage between AI in Circular economy, sustainable growth, and studies have impressed on adopting new business models for a more effective use of AI towards sustainable growth, in a circular economy

DISCUSSION:

The authors after having reviewed the above literature review, the current economic and global conditions, believe that given the current dimensions of problems in the world we are in, it is essential for us to accept that AI is closely linked to Circular economy and the linkage to sustainable economic growth, is growing and if applied properly can be of good help to emerging economies and countries to take the industries in the country on the path of growth and development, albeit in a sustainable manner. It appears that going forward in the future the role of circular economy in the GDP is steadily growing and may have implications towards sustainable goals of the UN as already formulated and if integrated as part of a national wide movement can be most useful in the sustenance of the economy.

- ♠ The importance of AI and circular economy can be better built into the university and college curriculum to mould the young minds in proper direction and this will greatly help in effective waste management, energy efficiency, and material reduction.
- ♠ Proper application of AI in circular economy, will lead to a sustainable business model that will help enhance output, facilitate more recyclable products, improve energy efficiencies and enable better allocation of resources across sectors. It will also help in identifying ways and means in which innovation can happen and help industries in recycling waste using new and emerging technologies albeit at reduced cost levels.
- ♠ AI in Circular economy will enable urban bodies and civic institutions planning and increase their ability to develop more value for a dollarspent, e.g. developing smart cities, and thus can enable service societies and communities on lower budgetary allocations.

- ♠ Thermal power plants can minimise the loss of energy generation and losses, using AI and regeneration technologies, bring down losses in transmission using, by AI applications integrated with other branches of engineering, e.g. material sciences, bio-engineering, etc.
- ♠ Deployment of regenerative and renewable resources based technologies will help in the process greatly for industries in Metals & Alloys, Chemicals, Engineering, automobiles, Other process industries etc. These will help the industry 4.0 in its mission to be more value adding and add strength, resilience and flexibility to the strategies, industries may like to plan for.
- ♠ Circular economy and AI applications therein can bring in revolutionary changes in approaches to consumers in health care, food, waste management sector and substantial cost, energy savings can arise. E.g. operations involving tools and equipments based on regenerative technologies, improvement in development towards material sciences, new processes and products may emerge. Also, investment, downtime to recovery in health care sector can reduce adverse side effects. The challenges on health care technologies may be tackled in a more effective manner than currently is, in the circular economy.
- ♠ Past studies have mentioned that the main challenge is the interface design and development, and automated synergy and perhaps circular economy model can help us in this regard by providing suitable inputs and solutions to take timely and appropriate action at lower investment threshold.
- ♠ Technology disruptors and Business incubators can come together with environment experts to resolve the issues facing current global problems effectively using AI in CE. In this regard the role of Govt is important to provide for an institutional framework that is sustainable and supportive. Thus regenerative and recyclable technologies need to be suitably encouraged by funding, incentivise from a system perspective. These actions can have the potential to change to urban and rural landscape to a great extent.
- ♠ AI enabled circular economy is capable of making the environment more sustainable and this reduces strain on resources both in the various business models involving industry and agriculture sectors. Manufacturing is going to be the main beneficiary if the integration of process and adopt of regenerative technologies is facilitated.
- ♠ Defence Sector and Space technologies can if adopting regenerative and reusable technologies lead to spin off in other sectors like manufacturing , It services, etc at a lower cost than can be thought of and these will likely transfer resources and technologies to start ups which can revolutionise the growth and industry sector in different industries. A suitable licensee model basis with revenue sharing or cost sharing modalities and investment using special purpose vehicles, can be perhaps thought of
- ♠ The entry of startups in these CE I4.0 area can use AI very effectively and create value on a sustainable basis across economies, and perhaps Indian experience can go a long way in reverse diffusion of technologies to other countries. With suitable govt interventions there appears be good prospects and opportunities in this regard.

♠ Environmental problems can better be dealt with by recourse to regenerative and reusable technologies, and will thus contribute to lower pollution of air, soil and water. This improves indirectly the yield from agriculture and can step up growth, output in long run.

Industries that manufacture toxic waste products – e.g; Metals, leather tanneries, Sulphuric acid, heavy metals consumption units like brass industry, bulb manufacturing , solid municipal waste treatment plants, landsites with industrial wastes can be quite beneficial for waste recycling and reprocessing, and perhaps can provide electricity to local bodies etc

LIMITATIONS OF STUDY

The study is an exploratory study and does not consider the limitations imposed on technology transfers, disparities in political systems and other factors which limit the free flow or diffusion of technologies. No empirical validation has been discussed.

CONCLUSION

The Importance of AI in Circular economy and its contribution and its role in Sustainable Economic growth is very vital indeed and it is a fact that we can ill afford to ignore. Effective waste management in all forms is a precursor to ecologically sustainable growth. As the global problems mount on all directions like global warming, population growth, resource constraints, meeting sustainable development goals, and income disparities widen across different economies and sectors, it becomes all the more necessary to have a better handle on how we use AI in Circular economy, for our benefit as between the various stakeholders and develop and nurture an eco-system that makes it mandatory. It also allows for additional incentives for players in the Circular economy for adopting AI technologies that can be directly linked to sustainable and eco –friendly economy in the long run. The linkage of AI to CE and its impact are clearly visible for us in the development of many products that can help members of society to meet their aspirations albeit at a lower level of resource utilisation in the circular economy and reduce usage of material, energy and resources, ultimately resulting in an affordable cost in long run.

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