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METAVERSE CONTRIBUTION TOWARDS SDG 9- INTERFACE AND INTERACTION

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ABSTRACT

The metaverse phenomenon -- gained a lot of focus during the COVID-19 outbreak. It can be related to meeting concerns about meeting Sustainable Development Goals assigned by the United Nations. Global warming changes the local and regional ecology and is one of the significant agendas and goals related to the SDGs. It can be linked to creating industry concerns to be innovative by applying ICT to bring in development and human well-being. In this context, the application of Metaverse technology can be highlighted. Even though there are several critics of Metaverse, an attempt has been made in this work to link the usage of Metaverse application to attaining SDG number 9 of industry infra of innovative and environment-friendly processes. The information for this work has been taken from the websites, mainly accessible from India. From an economic perspective, the benefits of employing this technique out ways the social critics and contribute towards sustainable practices in terms of opportunities for optimal utilization of human capabilities and efforts, saving man-hours. Finally, user discretion in applying and adopting the latest technology must be employed to mitigate the opposing side and promote the positive impacts of its sustainable application. This research paper explores the dynamic technology landscape, focusing on applying Metaverse technology for sustainable industrial infrastructure. It categorizes existing literature into technical and application-based segments. The study addresses fundamental questions regarding Metaverse applications, stakeholders, and associated concerns to enhance our understanding of its potential impact on future global development.

INTRODUCTION

Metaverse technology can be termed as application of Web 3.0 (Marcos Rogerio Mazzieri et al., 2022) or Web 3.0 (Kim, 2021) and as future of internet; is gaining a lot of attention of the academics and corporate in terms of applications and researched (Narin, 2021). This further is related to sustainability in many ways. Its application is still at the early stages (Tlili et al., 2023). The Sustainable Development Goals (SDGs) are a set of 17 global goals adopted by the pressing challenges achieve a sustainable future for all. In fact, as a fundamental issue, sustainability is critical and it can be hypothesized that the metaverse is capable of significantly make an impact on the- economic, environment, and the social life. Exploitation of natural resources due to population growth resulted into increased customer demand and increased waste and pollution; clubbing together has made concern of sustainability crucial.

On the pros side metaverse technology can substantially reduce carbon emission through replacing physical movement to virtual demos and interactions, physical training to simulated training, cyberspace to material space. Wider awareness and adoption by individuals and businesses can create more efficient systems and process, saving upon a lot of men- hours and financial resources. Thus, this advanced technology is supporting green networking technologies e.g. cloud storage of data resulting into less number of physical data warehouses. In this light it is imperative to design, development highly specialised and sophisticated software and hardware resources resulting into faster and more efficient computing power. On the other side another challenge is to have user-friendliness to bring in adoption by the masses along with the scalability issues. But on the cons side the possibility of social harm due to distancing individuals from the actual world cannot be ignored. Digital twin technology, a fundamental part of Metaverse can contribute towards intelligent manufacturing (Hassani et al., 2022) and reduce carbon footprints of handling pollution (Kshetri & Dwivedi, 2023). The

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metaverse employed wisely can boost up financial profitability, leading to economic growth. It is challenging to employ the metaverse technology wisely to balance with environmental, ethical, and social aspects.

Therefore, sustainability is another concern while employing metaverse technologies. Here an attempt has been made to connect it with the Sustainable Development Goals (SDGs) assigned by United Nations. This research on the application of Metaverse technology for sustainable industrial infrastructure post-COVID and its alignment with Sustainable Development Goal 9 is justified by its timely exploration of innovative solutions. Acknowledging critics, the study emphasizes economic benefits and draws information mainly from Indian sources for broader relevance. By categorizing literature into technical and application-based segments, it offers a comprehensive view. Advocating for Metaverse adoption, the research highlights its economic advantages, contributing to sustainable practices and user discretion for responsible technology use. This work significantly contributes to understanding the dynamic technology landscape in addressing global challenges and fostering a sustainable future.

MATERIALS AND METHODS

Understanding the dynamic technology landscape and application of latest technology towards the improvement in the future for the world are the major concern addressed in this work. The published work in this area can be classified in two segments of – technical and application based. Present article is limited to the scope of understanding the application and related issues through addressing following research questions.

Research Questions

Above background about Metaverse technology and sustainability define the scope of the study and addresses following questions to study

- What are the application of metaverse towards sustainable industrial infrastructure creation through innovative applications?
- Who all are the different stakeholders?
- What are the major concern areas related to same?

Data Collection

Various websites have been identified through Google search engine; along with the open online sources of published work as part of the literature review to present the conceptual and application side of Metaverse and related technologies. As there is a lot of overlapping in these upcoming technologies by way of advancement. The topic of this work being multidisciplinary is more towards the application side and not the technological in nature. That is the reason work presented is focused only on the environmental protection concerns through addressing SDG 9 of sustainable industrial infra. Consequently, only the latest developments of post 2019 have been included, highlighting the latest contribution in terms of its application even if it was already existing. Further this research can be extended to other aspects of the application of this technology for marketing and other commercial reasons.

DISCUSSIONS

Metaverse Technology

The concept of the metaverse refers to a virtual reality-based extension of the internet that enables users to engage in immersive and interactive experiences. It is a collective virtual shared space where individuals can access and interact with digital content, connect with others, and engage in various activities. Metaverse technology combines elements of augmented reality, virtual reality, and social networking to create a seamless and immersive virtual environment (Zhang et al., 2023).

Metaverse is “an interconnected web of social, networked immersive environments in persistent multiuser platforms” (Mystakidis, 2022). Scheiding asserted that the old concept of the year 1992 science fiction novel (Snow Crash) the technology concept of Metaverse came into prominence in the year 2021–2022. Four main scenario of this technology are- augmented reality, lifelogging, virtual world and mirror world (Kim, 2021).

Kim (2021) combing all different definition of Metaverse, gave a comprehensive definition- “it is an interoperated persistent network of shared virtual environments where people can interact synchronously through their avatars with other agents and objects.”

The metaverse has gained significant attention due to its potential applications across various domains, including entertainment, education, commerce, and social interaction. It offers possibilities for enhanced gaming experiences, virtual meetings and collaboration, virtual commerce platforms, and even virtual simulations for training and education.

The technology behind the metaverse involves advanced computer graphics, artificial intelligence, cloud computing, and high-speed internet connectivity. It requires sophisticated algorithms to render realistic virtual environments, track user movements, and enable real-time interactions with other users.

Tech companies like Facebook (now Meta), Epic Games, and Microsoft have invested heavily in metaverse development, aiming to create expansive virtual worlds with interconnected experiences (Kim, 2021). These companies are working on platforms that allow users to create and customize their avatars, explore virtual environments, interact with other users, and participate in various activities.

At the same time, the metaverse concept also raises concerns related to privacy, security, and access. Ensuring data protection, preventing exploitation, and ensuring inclusivity are critical challenges that need to be addressed as the metaverse evolves.

Growth in the Application of Metaverse Technology

The application of metaverse technology has expanded in recent years, driven by advancements in virtual reality, social networking, and immersive experiences. The outcomes are mostly researched in case of hospitality and education sector majorly (Tlili et al., 2023). Companies like Meta (formerly Facebook) are investing heavily in creating virtual environments where users can interact, collaborate, and engage in various activities. Virtual reality headsets and platforms are being developed to enhance immersion and enable seamless interactions within the metaverse (Bierhoff & Gable, 2021). The metaverse has found applications in socialization, commerce, entertainment, and education. Virtual communities are being created where users can connect and socialize, attending virtual events and concerts (Mallia & Scimeca, 2022). Virtual commerce platforms are enabling users to buy, sell, and trade virtual goods, including the use of non-fungible tokens (NFTs). Entertainment and gaming industries are incorporating metaverse elements, providing players with immersive experiences and shared virtual environments. Additionally, the metaverse is being utilized for remote workspaces, collaboration, and experiential learning in education and training settings (Bierhoff & Gable, 2021). These applications highlight the broad potential and versatility of metaverse technology in transforming various aspects of our lives. Increase in the application of metaverse technology have been driven by the growing interest and investment from major tech companies and the creative exploration of various industries. Here are some notable advancements:

- **Expanded Virtual Reality (VR) Experiences**: The metaverse has witnessed the development of more immersive and realistic VR experiences. Companies like Meta (formerly Facebook) are investing in VR headsets and platforms to enhance user immersion and enable seamless interaction with virtual environments and other users.
- **Social Metaverse:** One of the focuses of metaverse technology is social interaction. Platforms are being developed to create virtual communities where users can connect, socialize, and collaborate in virtual spaces. These environments enable users to attend virtual events, concerts, and conferences, fostering a sense of presence and shared experiences.
- **Virtual Commerce:** The metaverse is increasingly becoming a hub for virtual commerce. Brands and businesses are exploring the potential of virtual marketplaces, enabling users to browse, buy, and sell virtual goods and services. NFTs (Non-Fungible Tokens) have gained traction in the metaverse, allowing ownership and trade of unique virtual assets. Even in the area to B2B marketing application of AR and VR for virtual product demos, virtual trade shows are heavily utilised to create immersive experience for the prospects (Muneer, 2023). Due to its inherent characteristic of interactivity, it is predicted to change the advertising and marketing arena (Kim, 2021). Its applications needs to be adopted with precaution (Cheah & Shimul, 2023).
- **Entertainment and Gaming:** The entertainment and gaming industry has embraced the metaverse concept. Game developers are incorporating metaverse elements into their titles, allowing players to explore vast virtual worlds, interact with other players, and engage in various activities. Virtual concerts, live events, and streaming within the metaverse are also gaining popularity.
- **Virtual Workspaces and Collaboration:** Metaverse technology is being harnessed for remote work and collaboration. Virtual office spaces and meeting platforms offer immersive environments where remote teams can gather, communicate, and collaborate in a more engaging and interactive manner.
- **Education and Training:** The metaverse has shown promise in the field of education and training. Virtual classrooms, simulations, and training environments enable immersive and experiential learning. Students can explore historical sites, conduct scientific experiments, and engage in interactive educational activities within the metaverse. It has revolutionised the learning experience and outcome with the access to resources and research outcomes without restriction of time, location, language and disabilities (Hassani et al., 2022).

These recent developments reflect the growing adoption and exploration of metaverse technology across multiple industries, highlighting its potential to transform various aspects of our lives, from socializing and commerce to work and education.

Sustainable Development Goal

All the United Nations member countries have accepted as target to meet by the year 2030, total 17 goals, assigned in 2015. Outbreak of pandemic also made and emergent calling of action towards meeting these goals by the world. Eradication of poverty to balancing life on earth and water through inclusion, empowerment and usage of innovative technology and conducive infrastructure all are interrelated. Quality education and women participation all are linked to environmental concerns and thus preserving life on earth. Economic and social wellbeing are interconnected in these goals. These goals encompass a wide range of areas, including poverty eradication, quality education, clean energy, gender equality, and climate action. The SDGs aim to create a world that is economically prosperous, socially inclusive, and environmentally sustainable by 2030. They provide a comprehensive framework that guides governments, organizations, and individuals in their efforts to promote sustainable development. The SDGs are essential for tackling interconnected issues and ensuring a balanced approach to development. By working collectively towards these goals, aim is to build a more equitable and resilient world for present and future generations (United Nations, n.d.).

Sustainable Development Goal 9

"Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation" is the United Nations' Sustainable Development Goal 9. This goal recognizes the crucial role of infrastructure development, industrialization, and innovation in driving economic growth, creating job opportunities, and fostering sustainable development. This goal can be further sub divided into:

- Here resilient infrastructure refers to the development of reliable and sustainable infrastructure systems that can withstand and recover from natural disasters and other shocks. It involves investments in transportation, energy, water and sanitation, and information and communication technologies, among others. Resilient infrastructure is vital for improving productivity, enhancing connectivity, and ensuring access to essential services, particularly in vulnerable communities.
- Promoting inclusive and sustainable industrialization entails fostering the growth of industries that are environmentally friendly, socially inclusive, and economically viable. This involves supporting small and medium-sized enterprises, encouraging sustainable manufacturing practices, promoting resource efficiency, and facilitating technology transfer to developing countries. Inclusive and sustainable industrialization helps create decent jobs, reduce inequality, and promote sustainable economic growth.
- Fostering innovation is another key aspect of Goal 9. Encouraging research and development, promoting technological progress, and supporting innovation ecosystems can lead to the creation of new industries, products, and services that address societal challenges. Innovation can drive sustainable development by improving resource efficiency, enhancing access to information and communication technologies, and facilitating the adoption of clean and renewable energy sources.
- Achieving Goal 9 requires collaboration between governments, private sector entities, academia, and civil society organizations. It demands increased investments in infrastructure, technology, and research and development, along with policies that promote sustainable industrialization and innovation.
- Environmental protection is one of the critical issues in the Sustainability related and have gained significant attention in recent years. The concept of sustainability involves meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. It encompasses environmental, social, and economic aspects and aims to ensure long-term well-being and the preservation of natural resources. Environmental protection, on the other hand, focuses specifically on the conservation and management of the environment to prevent pollution, degradation, and the loss of biodiversity. It involves measures to mitigate the impact of human activities on ecosystems and promote the sustainable use of resources. Sustainability and environmental protection are interlinked and require collective action from individuals, organizations, and governments. They encompass a wide range of practices, including reducing greenhouse gas emissions, promoting renewable energy sources, conserving water and energy, adopting eco-friendly technologies, implementing waste management strategies, and protecting natural habitats.

Sustainability and Environmental Protection

Efforts in sustainability and environmental protection have been driven by scientific research, policy initiatives, and public awareness campaigns. Numerous international agreements, such as the Paris Agreement and the Sustainable Development Goals, highlight the global commitment to addressing climate change, biodiversity loss, and sustainable development. The role of business and industry is crucial in promoting sustainability and environmental protection. Many companies have adopted sustainable practices, incorporating environmental considerations into their operations, supply chains, and product development. This includes initiatives such as reducing carbon emissions, implementing circular economy principles, and ensuring responsible sourcing of raw materials. Public engagement and education are also vital in fostering a sustainable future. Individuals can contribute through conscious consumption, recycling, reducing waste, conserving resources, and advocating for sustainable policies and practices.

Dimensions of Sustainability and Application of Metaverse Technology

The metaverse technology is contributing towards addressing sustainability. It can contribute immensely towards achieving various SDGs, by transforming the material word, bringing digital world to compliment and thus contribute towards SDGs. Hassani (2022) in his work related digital to six of the 17 SDGs. In the same work scalability issue was also raised. Although the metaverse is a digital 3D Internet realm and is based on material infrastructure which necessitates the usage of natural resources and power for its production. Major challenge is to develop and construct its application and manage the implementation and adoption by the masses which is focused on sustainability. Therefore, feasibility and ethical usage of the metaverse is of great concern. It's a concern to explore the immersive digital space effect on environment, economies, and society leading to sustainability. Metaverse technology, with its immersive and interactive capabilities, holds potential for applications in the sustainability efforts. Here are some ways metaverse technology can contribute to SDG 9 and thus towards environmental conservation:

- **Virtual Collaboration and Communication:** Metaverse platforms can facilitate virtual meetings, conferences, and collaboration, reducing the need for physical travel. By minimizing transportation-related emissions, metaverse technology can contribute to lowering carbon footprints (Dahlstrom, 2020). Telework through metaverse platforms have been found to be seen positively by people towards relocation from major cities hence reducing population pressure (Choi, 2022), hence pollution and other sustainability related issues can be avoided.
- **Virtual Training and Simulations:** The metaverse can be used to create virtual training programs and simulations for environmental education and conservation. It enables users to engage in virtual field trips, explore ecosystems, and learn about sustainable practices without physically impacting the environment. Application of game engines by creating digital humans have application in simulating the processing of materials to abstract concepts like creation of culture for different industries- manufacturing and construction to architecture and engineering (Chia, 2022). Learning music and instruments (Turchet, 2023) to training in aviation has always been one of the major

application of simulation and the empirical studies reported favourable perception by the trainees (Ziakkas et al., 2023).

- **Public Awareness and Advocacy:** Metaverse environments can serve as virtual spaces for raising public awareness about environmental issues. Users can participate in virtual campaigns, educational exhibits, and interactive experiences that promote sustainable behaviours and conservation efforts. Another important area is sharing economy application by the users (Pamucar et al., 2023) e.g. sharing transportation.
- **Sustainable Virtual Marketplaces:** Virtual commerce within the metaverse can promote sustainable consumption by facilitating the exchange and trade of virtual goods instead of 3 physical products (Cheah & Shimul, 2023). This can reduce resource consumption, waste generation, and carbon emissions associated with traditional manufacturing and distribution (Gibbs & Deutz, 2018). Even the term "creative economy" (Marcos Rogerio Mazzieri et al., 2022) is the combination of ICT and human creativity which has brought in digital currencies Non-Fungible Tokens (NFT) as one of blockchain network based currencies, crypto assets. Rathore (2023) highlighted addressing concern of sustainable manufacturing and marketing inclusion of latest metaverse technologies. Integration of AI (consumer sentiment and emotion analysis) and metaverse forecasting the trends is imperative in the fashion and apparel industry (Rathore, 2023). Cosmetic industry (Lee & Kwon, 2022), Fashion industry (Rathore, 2023), Tourism (Monaco & Sacchi, 2023) Music and entertainment (Turchet, 2023) to name a few have potential for mass adoption. Another important area is sharing economy application by the users (Pamucar et al., 2023) e.g. sharing transportation.
- **Environmental Monitoring and Research:** The metaverse can support environmental monitoring and research by providing a platform for real-time data visualization, analysis, and collaboration. It can facilitate the integration of remote sensing data, environmental models, and citizen science efforts, contributing to improved understanding and decision-making in environmental management (Waldhoer & Haunold, 2021). All the above concerns end with the carbon emission. Thus metaverse can make an ecosystem with more virtual communication, collaboration through remote working and resulting into environment protection (Choi, 2022).
- **Production and manufacturing:** Specific application to digital twin application in the area of smart manufacturing, sustainable production, product life-cycle management (PLM), logistics and circular economy, building-information modelling (BIM), smart constructions and maintenance (Hassani et al., 2022) could support development of a sustainable industrial infrastructure. Engineering and construction industry has been revolutionised with the inclusion of metaverse technology to reach to improved efficiency, safety and sustainability (Wang et al., 2022). In specific the common being the energy sector can be the source towards meeting sustainability goals (Singh et al., 2022). Cosmetic industry (Lee & Kwon, 2022), Fashion industry (Rathore, 2023), Tourism (Monaco & Sacchi, 2023) Music and entertainment (Turchet, 2023) all are gearing up in the adoption of AR and VR technologies. Thus, these applications demonstrate how metaverse technology can be harnessed to raise awareness, facilitate sustainable behaviours, and provide innovative solutions for environmental protection and conservation. 6. Conclusion Outbreak of COVID'19 is one of major reason for the mass adoption of virtual conferencing platforms- Zoom MS Teams (Rospigliosi, 2022). Specifically that made easy to address concerns for health (Lee & Kwon, 2022). Saving upon fuel and travelling without fear of the virus were outcomes to promote virtual teamwork and work from home. Human and computers are complimenting and creating economies and efficiencies. AI based manufacturing to marketing are move towards attaining sustainable industry (product designing to testing, price optimisation, market segmentation to routing and scheduling and logistics management) (Rathore, 2023). There are concerns about the future of metaverse (Tlili et al., 2023). To meet Goal and concerns for developing sustainable green industrial infrastructure inherited with innovative technology i.e. application of Metaverse can be highlighted for the various stakeholders Metaverse devices/ service providers- a new industry of developers of metaverse technologies and devices which is challenging in terms of innovation and continues improvements. Ethical behaviour is expected from the service provider. In a recent publication framework for ethics is suggested for the three platforms namely for different computing devices, for intermediary platforms, and for physical computing devices (Han, 2022) Industry- driving the change through adoption in manufacturing to selling to service, which necessitates investment in technology adoption and training of employees as well user friendly. Policy-makers- are majorly needs to concern with the balance in having social implication as industry is already driven by the profit motives; wherein user should get cheated. Risk of taking the virtual environment and ignoring the reality needs to be attended critically, especially for learners (Rospigliosi, 2022). The concern of using ethically the Big Data generated due to power of Metaverse technologies is critical (Anshari et al., 2023), this may isolate or bankrupt citizen. Cyber laws to consumer awareness and online socialisation code of conduct needs to frame. Consumers- economy to efficiency all are in favour of consumers, yet security and privacy concern require users to be more vigilant and apply due diligence. Another requirement is to keep abreast and to continue updating to remain smart user.

CONCLUSIONS

Outbreak of COVID'19 is one of major reason for the mass adoption of virtual conferencing platforms- Zoom MS Teams (Rospigliosi, 2022). Specifically that made easy to address concerns for health (Lee & Kwon, 2022). Saving upon fuel and travelling without fear of the virus were outcomes to promote virtual teamwork and work from home. Human and computers are complimenting and creating economies and efficiencies. AI based manufacturing to marketing are move towards attaining sustainable industry (product designing to testing, price optimisation, market segmentation to routing and

scheduling and logistics management) (Rathore, 2023). There are concerns about the future of metaverse (Tlili et al., 2023). To meet Goal 9 and concerns for developing sustainable green industrial infrastructure inherited with innovative technology i.e. application of Metaverse can be highlighted for the various stakeholders-

Metaverse devices/ service providers- a new industry of developers of metaverse technologies and devices which is challenging in terms of innovation and continues improvements. Ethical behaviour is expected from the service provider. In a recent publication framework for ethics is suggested for the three platforms namely for different computing devices, for intermediary platforms, and for physical computing devices (Han, 2022)

Industry- driving the change through adoption in manufacturing to selling to service, which necessitates investment in technology adoption and training of employees as well user friendly.

Policy-makers- are majorly needs to concern with the balance in having social implication as industry is already driven by the profit motives; wherein user should get cheated. Risk of taking the virtual environment and ignoring the reality needs to be attended critically, especially for learners (Rospigliosi, 2022). The concern of using ethically the Big Data generated due to power of Metaverse technologies is critical (Anshari et al., 2023), this may isolate or bankrupt citizen. Cyber laws to consumer awareness and online socialisation code of conduct needs to frame.

Consumers- economy to efficiency all are in favour of consumers, yet security and privacy concern require users to be more vigilant and apply due diligence. Another requirement is to keep abreast and to continue updating to remain smart user.

The future research scope in the field of Metaverse Technology is multifaceted. Firstly, there is a need for rigorous investigation into the ethical dimensions and privacy concerns associated with the widespread adoption of metaverse technologies. This entails exploring potential risks related to user data protection, digital rights, and establishing ethical frameworks for metaverse platforms across different computing devices. Secondly, in-depth studies on the long-term environmental impact of metaverse technology are crucial, focusing on its carbon footprint and sustainability challenges. Research should delve into the feasibility and ethical use of the metaverse, emphasizing its effects on environmental, economic, and societal aspects. Additionally, future research could examine innovative applications of metaverse technology in addressing specific Sustainable Development Goals (SDGs), particularly SDG 9, by investigating its role in developing resilient infrastructure and fostering sustainable industrial practices. Ongoing monitoring of emerging trends, challenges, and user experiences across diverse industries will contribute to the responsible development and adoption of metaverse technologies. This comprehensive research agenda will provide valuable insights for shaping the ethical, environmental, and societal implications of the evolving metaverse landscape.

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