Metaverse and Circular Economy

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The revolutionary concepts of the Metaverse and Circular Economy are poised to reshape the future of society, academia and all business sectors. The Metaverse as a digital realm promises to transform peoples' way of life, while circular economy offers a sustainable and regenerative approach to economic growth. Together, these concepts can be combined to unlock new opportunities, drive innovation, and address pressing challenges facing humanity. Within this new era of technological and environmental transformation, understanding the capabilities and potential of the Metaverse intertwined with the circular economy is crucial for individuals and nations alike.

1. Introduction

The root of innovation acceleration lies in the power of imagination. Solving urgent issues like climate change, waste accumulation, loss of biodiversity and sustainability delay requires a tangible vision for interconnecting disparate elements of today's world like the circular economy, sustainability, digitalization, and the Metaverse. In recent years, immersive technologies have witnessed rapid growth, binding together imagination and industrial processes. Although their full potential has not yet been reached, Augmented, Virtual and Mixed Reality (AR/VR/MR), Artificial Intelligence (AI), and Internet of Things (IoT) markets are expected to reach more than $11.4 billion in revenue by 2028 (Statista, 2023a) while the Metaverse is expected to reach 937 billion dollars in revenue by 2030 (Statista, 2023b).

The Metaverse is an emerging concept envisioned to transcend hypothetical synthetic environments and link them to the physical world (Ellen MacArthur Foundation, 2022)**.** However, the term Metaverse was first mentioned in 1992 by a fiction novel "Snow Crash" as a mix of "meta" meaning after and beyond "Universe" (Vox, 2023). The author asserts that within this virtual environment, individuals possess the ability to construct various structures in three dimensions, including but not limited to shops and offices, which are ostensibly accessible to other users (Abbate et al., 2023).

During the 2022 MetaConnect presentation, Mark Zuckerberg redefined the Metaverse as a network of 3D virtual worlds, which prioritize social connection (The New York Times, 2022). This definition highlighted the crucial role of social interactions withing the Metaverse, which goes beyond mere recreational activities. This Metaverse is envisioned as a virtual replica of the physical world, offering users the ability to work, learn and trade within its digital confines. Evidence of this was shown throughout the COVID-19 pandemic, which forced many to work and learn remotely. By delving deeper into a topic, users can better comprehend it and engage in a socially interactive learning environment (Abbate et al., 2023).

2. The role of Metaverse environment in circular economy strategy

The Metaverse environment can play a critical role in circular economy strategy by providing a platform for sustainable consumption and production, in line with the Sustainable Development Goal SDG 12 (Responsible consumption and production) of the United Nations (UN). It can reduce physical consumption by applying physical concepts into the virtual world, encourage the sharing economy, and educate users on sustainable practices (Dwivedi et al., 2022; Pappas et al., 2022a). As the Metaverse grows and evolves, it has the potential to become an essential tool for promoting a circular economy in the real world.

An example of this lies in fashion. As the fashion industry constitutes one of the most polluting industries in the world, second only to food and shelter, mitigation of its adverse sustainability effects (i.e., waste production, greenhouse gas emissions, water and energy consumption, raw material consumption and depletion etc.) is crucial (Papamichael et al., 2022a). The digitalization of the fashion industry aims to enhance the efficiency of physical product design, production, and business operations, while also promoting sustainability using digital tools. The emergence of the Metaverse as a parallel virtual reality world has opened up a new frontier for digital fashion. Innovations in this field can be categorized into four distinct themes: digital design and e-prototyping, digital business and promotion, digital human and Metaverse, and digital apparel and smart e-technology (Sayem, 2022). In the context of Metaverse, AR has the potential to help customers and consumers choose the right outfits virtually (Dwivedi et al., 2022). For instance, Adidas incorporated a virtual try of their shoes, allowing users to engage in virtual activities and transactions (Kar and Varsha, 2023). Therefore, instead of traveling to a physical store to purchase goods, users can access virtual stores within the Metaverse and purchase digital products or services thus reducing the environmental impact associated with transportation and the production of physical goods.

3. Circular economy strategies and Metaverse

Linking the concepts of circular economy with the Metaverse aids the utilization of virtual products and services created and used without any physical resources being consumed, digital recycling where digital products can be recycled and repurposed without any waste being generated (i.e. virtual clothing items and accessories remodelled, reused or repurposed), sustainable virtual infrastructures with low energy consumption and carbon emissions, as well as Architecture-Engineering-Construction (AEC) for designing buildings and cities in a semi-realistic digital world (Baghalzadeh Shishehgarkhaneh et al., 2022; Kanak et al., 2022). In this context, the interconnection of the Metaverse, circular economy and smart cities will come in the foreground as a main area of development in the future, due to the necessity of both technology and waste mitigation (Dwivedi et al., 2022; Maleki Vishkaei, 2022).

One pressing issue that has to be addressed is the energy-intensive operation of servers. Realizing the Metaverse will require a superabundance of cloud-streamed data, which require a lot more computing power and coupled with the number of consumers using these services the energy consumption maybe prohibitive. For a fully operational Metaverse to become reality the energy and carbon footprint issues must be solved and this is not easy (Zalan and Barbesino, 2023).

At the same time, education and awareness in the context of the Metaverse can be used to alert the public about circular economy principles and encourage them to adopt sustainable behaviours. For instance, virtual events and simulations can be used to demonstrate the benefits of reducing waste and recycling materials. In addition, the Metaverse environment can be used to promote waste prevention strategies (e.g., food waste, fashion libraries, etc) as well as to design and establish any waste strategies emphasis on SDGs, Fitfor55 package, European Green Deal, etc. In the case of the fashion industry, sharing virtual resources such as digital assets, services, and experiences promotes circularity in the industry by extending the lifespan of goods and reducing waste. Simultaneously, the Metaverse can be used to educate users, employers, employees and key players along the production line of the fashion industry about sustainable consumption and production practices including recycling, reuse, recovery, remanufacturing, refurbishment, renting, prevention etc. Consequently, virtual and engaging education can translate into real-world practices, further promoting circular economy principles (Eliades et al., 2022; Papamichael et al., 2022b; Pappas et al., 2022a, 2022c).

4. Metaverse and solid waste management

In order to tackle the concept of circular economy, adequate waste management practices are vital. Yet, when searching SCOPUS database based on PRISMA principles (Papamichael et al., 2023) for results concerning "waste management" and the "Metaverse", only one result was given (2022 IEEE 13th Annu. Ubiquitous Comput. Electron. Mob. Commun. Conf. UEMCON 2022," 2022), despite the importance of the topic. At the same time, "Metaverse" and "Circular Economy" returned merely two results (Baghalzadeh Shishehgarkhaneh et al., 2022; Kanak et al., 2022), which is disproportionate to the accelerating transition towards Industry 5.0. At the same time, the combination of keywords for Metavers and circular Defense as well as "Metaverse" and "army" returned zero results. On the other hand, "Metaverse" and "Defence" returned ten relevant records, but none of them were dealing with circular economy strategy and/or energy security as most of them were emphasizing on cyber security.

The integration of waste management into the Metaverse can aid in reducing physical waste by providing a virtual space for human interaction, businesses, education, thus reducing the need for physical resources (Sayem, 2022). At the same time, and as was with the case of circularity, the encouragement of sustainable behaviour through education and transfer of knowledge on sustainable practices (i.e. recycling, composting, reduction of waste etc.) can simulate real-world scenarios and show the public the impact of everyday habits onto the three sustainability pillars (environment, economy, society). Simultaneously, repurposing and recycling of goods and materials can be enhanced, among which are those which would otherwise be considered as waste. Specific to waste management, the Metaverse has the potential to be utilized as a repository of data for waste management strategies like consumption patterns, waste generation, infrastructure (bins per capita) as well as inform public authorities and policy makers on the viability of existing or crafted urban or national strategies (Bibri, 2022).

In this regard, the Metaverse could provide a platform for collaboration and information sharing among waste management professionals and policymakers regarding waste management legislation. For instance, virtual reality simulations could be used to design processes, simulate complex operations, offer virtual site visits to plants and teach waste management techniques to individuals and organizations, allowing them to practice waste reduction, reuse, and recycling in a safe and controlled environment. Virtual conferences, workshops, and meetings could be held in the Metaverse, allowing individuals from different parts of the world to come together to share knowledge, discuss best practices, and develop new solutions to solid waste management challenges (Krupnova et al., 2020). Aligned as such, environmental management Systems (i.e. ISO 14001) can be explored into a virtual space by incorporating virtual meetings and collaboration, virtual training and education, virtual audits and assessment as well as simulations and modelling (Papamichael et al., 2022b; Zorpas, 2020).

As expected, the transportation of everyday activities like education, travel, business, human interaction and other is a recurring theme for both circular economy and waste management as indicated in Figure 1. This is only natural as with the coming of the fifth industrial revolution, otherwise known as Industry 5.0, data and knowledge sources concerning societal choices are available online. The transition to Industry 5.0 marks a new era of smart and connected manufacturing, where machines and humans work together in symbiotic relationships to achieve unprecedented levels of productivity and efficiency (De Giovanni, 2023).

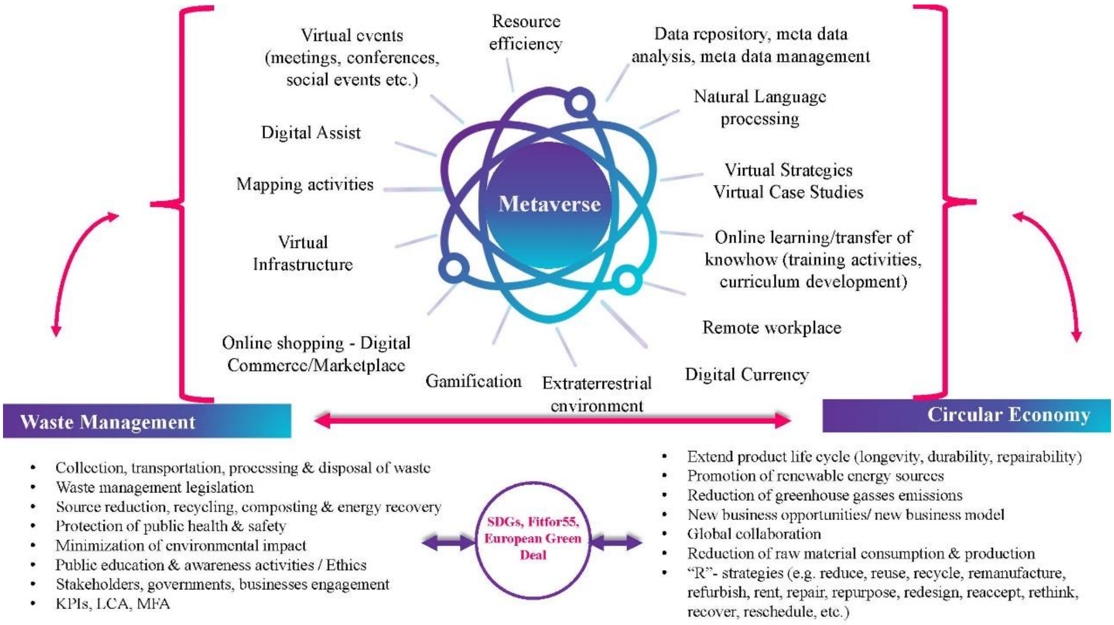

Figure 1: Correlation of waste management strategies, circular economy and the Metaverse (figure created by the authors).

In this context, as millions of people utilize massive multiplayer online gaming platforms connected with the virtual world, the notion of virtual communities including businesses, trades and other are tolerated and encouraged. Virtual worlds uphold a massive potential to bring new added value to the user by creating something that cannot be shown or done in reality traditional environments (Abbate et al., 2023).

Gamification is the use of game design principles in non-game contexts to motivate and engage people in certain activities (Pappas, 2021). For instance, Pappas et al. (2022a) used a gamified tool for educational on waste management on urban settings. The simulation created an engaging environment for students to interact, learn and comprehend the impact of everyday activities or urban planning strategies on waste management and sustainability. With the rise of the Metaverse, game designers are creating more immersive and interactive games that take advantage of the social and creative aspects of virtual worlds. As a result, gamification is becoming more popular in areas such as education, fitness, and marketing (Avraamidou et al., 2019; Capellán-Pérez et al., 2019; Oppong-Tawiah et al., 2020; Pappas et al., 2020; Pappas et al., 2022c; Strebkowski et al., 2018).

In waste management, the Metaverse has the potential to revolutionize how civil society perceives waste. Engaging virtual environments which simultaneously provide data on waste management practices through the use of Key Performance Indicators (KPIs), Life Cycle Assessment (LCA), Material Flow Analysis (MFA) and other quantifying tools, can provide a platform for businesses and organizations to test and implement circular economy practices (Cleary, 2009; Corona et al., 2019; Loizia et al., 2021; Millette et al., 2019; Papamichael et al., 2022b; Pappas et al., 2022a). Virtual simulations can be used to model and analyse different waste management strategies, allowing companies to test and refine their circular economy initiatives before implementing them in the real world, but based on real life data in real life scenarios, in a virtual life like environment (Ning et al., 2021).

5. Circular Metaverse in Defence sectors

More than that, the advancement in technology, specifically in the field of artificial intelligence and the development of Metaverse approaches, has the potential to revolutionize the way we think about Defense planning in relation to energy use and development. By utilizing these tools, more intelligent and sustainable defense strategies can be created, which take into account the complex interplay between energy production and consumption in connection with security and resilience. One potential application of this technology is in the field of sustainable energy. By applying Metaverse approaches, virtual simulations can be developed, to allow the exploration of different energy production scenarios and the assessment of their potential impact on defense energy resilience and autonomy. This process is essential identifying vulnerabilities and assessing risks, developing strategies and practices in mitigating them and ensuring defense energy resilience. Similarly, in defense (capability) planning, the use of AI can help with the analysis of large volume of data and the identification of patterns that may indicate potential security threats and risks. This methodology will underpin defense decision-making on how to optimize energy modes in Defense and allocate efficiently the resources to ensure the effective and secure deployment of armed forces to safeguard national interests as well as control and monitor resource inputs and waste in regards to waste management in Defense. Overall, the integration of AI and Metaverse approaches into defense planning and energy development has the potential to optimize processes, reduce costs, promote the application of sustainable and affordable energy models, reduce energy consumption and create conditions for reaching climate-neutral models, thereby contributing to EU's energy and climate-related objectives.

Several case studies have shown the potential of Metaverse approaches in redesigning defense planning and strategies for developing intelligent and sustainable energy models. For example, the United States Department of Defence has implemented a virtual environment called the Energy Security and Climate Change Strategic Environment (ESCCSE), which simulates different scenarios related to energy security and climate change (European Defense Agency, 2021). The ESCCSE allows for the evaluation of different energy-efficient measures and the development of sustainable energy strategies. Another example is the European Union's Defense Research and Innovation (DRII) project, which aims to develop a virtual environment for the evaluation of energy-efficient measures in Defense planning (European Commission, 2021). The project involves the collaboration of different stakeholders, including military personnel, energy experts, and policymakers, which can enhance the development of sustainable energy strategies.

6. Conclusion

The intersection of the Metaverse and circular economy presents an exciting yet challenging opportunity. Even though the Metaverse can be utilized to provide a platform for virtual circular economies where resources are conserved, waste is minimized and products are reused and repurposed, the development and maintenance of such system requires a significant investment of resources, expertise, cooperation and innovation among stakeholders and the research community. Issues relating to data privacy, security and ownership will come to the foreground and will need to be addressed to ensure that the benefits of the Metaverse and circular economy are accessible to all. Overall, the success of this convergence will depend on a collective effort to address these challenges and leverage the full potential of emerging technologies. The International Solid Waste Association (ISWA) will and is required to play a fundamental role to this transition, as it constitutes one of the key players regarding sustainable development and initiative, by promoting and engaging with waste management tools based, without limitation, on a combination with the Metaverse, AI and IoT. Through its transfer of knowledge and continuous research efforts of waste management professionals, academia, policymakers, by utilizing the platform of ISWA for knowledge exchange, the time to embody and embrace future endeavors and technological advancements is now. In addition, Waste Management and Research Journal and ISWA, will have a vital and important role to play as they intend to lead this attempt.

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