



Research Article

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What Can we See Inside the Crystal Ball? Exploring Opportunities and Challenges for Metaverse and Circular Economy

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Abstract

Metaverse is a virtual world that offers endless possibilities for entertainment, education, and social interaction. Whereas circular economy deals with the principle of reduce, reuse, and recycle which helps in waste elimination and boost continuous resource availability. However, there are challenges to promoting a circular economy in the metaverse. One of the challenges is ensuring that everyone has access to it, as there is still a digital divide. Additionally, it is challenging to track the lifecycle of virtual products and ensure they are properly recycled or reused. Finally, it is necessary to coordinate virtual and real-world initiatives to create a comprehensive circular economy system. Despite these challenges, many opportunities exist for promoting a circular economy in the metaverse. One opportunity is creating virtual marketplaces for second-hand goods. Another opportunity is using virtual reality to simulate the environmental impact of different products and production methods. Finally, researchers can develop virtual training and certification programs for sustainable practices in the metaverse. The challenges that need to be resolved to create a sustainable future for both the real and metaverse are discussed here. Overall, the implications of using the metaverse for the circular economy are promising but require careful consideration and collaboration between virtual and real-world efforts. Researchers can contribute to the development of a more equitable and sustainable future by understanding these concepts.

Keywords: Metaverse; Circular Economy; Sustainability; Virtual Reality; Blockchain; Digital divide

1. Introduction

The concept of the metaverse refers to the convergence of augmented reality, virtual reality, and the web, which enables people to interact with one another in a more immersive manner. Metaverse can transform people's lifestyles by opening new ways of working, learning, socializing, and playing (Abbate et al., 2023). The concept of the circular economy (CE) is an approach that aims to reduce pollution and waste by design (Tang et al., 2022). It is a sustainable way to increase economic growth and address environmental and resource issues. The concept of CE is based on the 3R principle of reducing, reusing, and recycling. It aims to minimize the use of resources in the first place while maximizing the lifespan of materials and products (Liu et al., 2023). Although the concepts of the metaverse and the circular economy are still in their early stages of development, they can have a substantial impact on the business and society sectors (Papamichael et al., 2023). Researchers can help shape the development of these concepts by understanding their potential. By working together, the circular economy and metaverse can address some of the most critical issues facing the world (Elobeid & MacArthur, 2023). Educational institutions and the public can use the metaverse to promote the circular economy and raise awareness about it. By creating an interactive and immersive environment, the platform can help make the concept more accessible to a wide audience. The two can work together to tackle some of the world's most challenging problems and find new opportunities.

Imagination is the key to accelerating innovation. A vision that connects the various elements of the world, such as the digital economy, sustainability, and the Metaverse, will help solve some of the most challenging issues of our time. The rapid emergence and growth of immersive technologies have been attributed to their ability to bind together the various industrial processes and imagination. Although their full potential is still not known, the market for virtual and mixed reality, augmented, and AI is expected to reach a total of \$11.4 billion by 2028 (Metaverse Market Size 2022-2030 | Statista, 2023). The Metaverse, on the other hand, is expected to reach a revenue of around \$937 billion by 2030 (Statista, 2023). The concept of the Metaverse is an emerging idea that proposes the link between the physical world and simulated environments (Ning et al., 2023). Although the metaverse term was mentioned in 1992 novel (Huddleston, 2021), it has since been captured various researchers attention (Zenou, 2022; Elobeid & MacArthur, 2023). Individuals can construct various structures within the virtual environment, such as offices and shops (Barrera & Shah, 2023). During the MetaConnect 2022 presentation, Facebook CEO Mark Zuckerberg referred to the virtual world as a network of interconnected social spaces. He noted that the Metaverse concept goes beyond merely recreational pursuits. In recent years, the concept of the metaverse has captured the imagination of individuals and industries alike (Mac et al., 2022).

Metaverses are virtual worlds that have the potential to significantly change how people consume, work, and live. In the circular economy, this type of virtual world can be utilized to develop novel and innovative approaches to enhance efficiency, minimize waste, and promote sustainability and eco-friendliness. Here are some practical examples of how the metaverse is being used in the circular economy today:

- a. Virtual product design and manufacturing: Companies like IKEA and Nike are using the metaverse to create virtual showrooms and design studios where customers can design their own products and see how they will look in their homes or on their bodies before they buy them. This can help to reduce returns and waste.
- b. Virtual supply chains: Companies like Walmart and Target are using the metaverse to create virtual supply chains where they can track the movement of goods and inventory in real time. This can help to improve efficiency and reduce the environmental impact of physical supply chains.
- c. Product lifecycle management: Companies like Coca-Cola and Unilever are using the metaverse to track the lifecycle of their products from manufacturing to disposal. This information can be used to improve the circularity of products and reduce waste.

- d. Consumer education and engagement: Companies like TerraCycle and Loop are using the metaverse to educate consumers about the circular economy and encourage them to make more sustainable choices. For example, TerraCycle is developing a virtual recycling platform where consumers can recycle their waste products in exchange for rewards. Loop is developing a reusable packaging system for food and beverage products where customers can order products in reusable packaging and then return the packaging to Loop for cleaning and reuse.

These are just a few examples of how the metaverse is being used in the circular economy today. As the metaverse continues to develop, we can expect to see even more innovative ways to use this technology to promote sustainability and reduce waste. In addition to the above examples, here are some other potential uses for the metaverse in the circular economy:

- a. Virtual marketplaces for used goods: The metaverse could be used to create virtual marketplaces where consumers can buy and sell used goods. This could help to extend the lifespan of products and reduce waste.
- b. Virtual repair shops: The metaverse could be used to create virtual repair shops where consumers can get their products repaired instead of replacing them. This could help to reduce waste and extend the lifespan of products.
- c. Virtual recycling centers: The metaverse could be used to create virtual recycling centers where consumers can easily recycle their waste products. This could make recycling more convenient and accessible, and it could also help to reduce waste.

Overall, the metaverse has the potential to play a significant role in the transition to a circular economy. By providing a platform for virtual product design, manufacturing, supply chain management, product lifecycle management, and consumer education and engagement, the metaverse can help to reduce waste, improve efficiency, and create a more sustainable future.

2. Research Gap

The metaverse has the potential to be a powerful tool for waste management and the circular economy. However, there is currently very little research on this topic. A search of the SCOPUS database for results related to the topic of waste management and the metaverse only yielded one result. Very few results came up for the concepts of the circular economy and the metaverse (Bibri, 2022; Bibri & Allam, 2022). This is disproportionate to the increasing number of studies that are focused on the circular economy's transition to Industry 5.0 (Lin et al., 2018). There are a few reasons why there is so little research on the metaverse and waste management. One reason is that the metaverse is still a relatively new technology. Another reason is that the metaverse is often seen as a space for entertainment and gaming, rather than a space for serious applications like waste management.

Despite the lack of research, there are several ways that the metaverse could be used to improve waste management. For example, the metaverse could be used to create virtual waste management facilities that would allow people to learn about waste management and how to reduce their waste. The metaverse could also be used to create virtual recycling centres that would allow people to recycle their waste more easily. The metaverse could also be used to track waste and its movement through the supply chain. This would help to identify areas where waste is being generated and where it is being disposed of. This information could then be used to improve waste management practices and reduce the amount of waste that is produced. Overall, the metaverse has the potential to be a powerful tool for waste management and the circular economy. However, more research is needed to explore the full potential of this technology.

3. Post-Pandemic Metaverse environment and Policies for Circular Economy

The metaverse is an evolving technology that can potentially address some of the most critical issues of the world. In 2022, scientists must explore the creation of virtual environments that can help cut

down on waste and foster a more sustainable economy. The concept of the circular economy refers to a framework that enables businesses and people to work together seamlessly while managing their use of resources (Santschi, 2022). Despite its positive aspects, it remains a buzzword due to various factors such as market failures and physics. In the circular economy, the metaverse can help us solve various challenges by allowing us to reuse, share, and create resources more efficiently. For instance, by utilizing the metaverse, we can design and produce products that are easier to repair and more durable. Furthermore, we can utilize the platform to establish virtual marketplaces for selling and buying used goods. Although it's still in its infancy, the metaverse can serve as a powerful tool for enhancing sustainability. In 2022, researchers must examine how we can integrate the metaverse into the circular economy.

The Metaverse can play a vital role in the circular economy by providing a platform that enables sustainable production and consumption. This can be done through the application of physical concepts to the virtual world (Awan & Sroufe, 2022). It can also help promote the sharing economy by educating users about sustainable practices. As the Metaverse continues to evolve, it can serve as a valuable tool that can help promote a circular economy in practice. One of the most important factors that can be considered when it comes to promoting a circular economy for reducing its environmental impact (Yan, 2022). It is therefore important that the industry takes the necessary steps to reduce its greenhouse gas emissions and other harmful effects. The rapid emergence and evolution of digital technology has revolutionized different industries. It has allowed it to improve the efficiency of its operations and promote sustainability by using tools that are not only more accurate but also more flexible.

This virtual reality space, where people can interact and engage with digital environments, has the potential to revolutionise the way we live, work, and consume. Simultaneously, the circular economy has emerged as a crucial solution to address environmental challenges and promote sustainability. Combining these two concepts can reshape our consumption approach and create a more sustainable future. The metaverse offers a unique platform for individuals to explore and experience digital worlds. It provides an immersive and interactive environment where people can connect, collaborate, and create. The goal of the Metaverse is to provide people with the ability to work, learn, and trade from their virtual environment. This concept was demonstrated during the COVID-19 pandemic, as many individuals had to work from home (Kerdvibulvech, 2022). By taking a deeper dive into a given topic, people can improve their understanding and engage in a more interactive learning environment.

With advancements in technology, the possibilities within the metaverse are expanding rapidly (Garbarova and Vartiak, 2022). From virtual reality headsets to haptic feedback devices, the tools for experiencing this virtual realm are becoming increasingly accessible (Kopac et al., 2022). At the same time, the circular economy is gaining recognition as a sustainable economic model that aims to reduce waste and promote resource efficiency (Jasečková et al., 2022). Unlike the traditional linear economy, which follows a "take-make-dispose" approach, the circular economy focuses on minimizing waste and keeping products and materials in use for as long as possible (Fabus et al., 2023). It encourages recycling, reusing, and repairing products rather than discarding them.

4. Metaverse and Sustainability

The term "Metaverse" has been buzzing since 2021 by Facebook, and it refers to the convergence of digital, augmented, and virtual worlds. Some of the platforms that allow users to interact with the metaverse include Decentraland, Mirandus, and Sandbox. They also allow users to use virtual currency, which is commonly referred to as crypto wallets. Virtual reality is becoming more prevalent, with many people using devices such as the VR headset known as the Oculus Rift. Through the metaverse, users can create their own avatars and explore the world. They can also interact with other people and travel across the globe. It allows them to make money by playing games and going to concerts. Although the metaverse is still in its development stage, it's clear that it will have a far-

reaching impact on how people live. The concept of the metaverse has various positive aspects, such as reducing pollution and making people travel less. However, it can also have negative impacts. The rise of the metaverse could cause an increase in greenhouse gas emissions. Cloud computing and virtual reality use a lot of energy. A study revealed that training a single artificial intelligence (AI) model could result in over 600,000 pounds of carbon dioxide emissions. By 2030, cloud gaming could contribute to the rise of carbon emissions (Even Though It's Virtual, the Metaverse Does Actually Impact the Environment, 2022). It is also expected to use more energy due to the need for high-quality images. According to some companies, such as Microsoft and Facebook, they have promised to reduce their emissions as per COP26 (Nadanyiova et al., 2023). However, this doesn't mean they will follow through with the promise. Instead, they will continue to make vague environmental investments (Kopac et al., 2022). The development of virtual reality technology has the potential to encourage people to buy new equipment, which could result in an increase in e-waste. It's currently up to the major corporations to find sustainable ways of creating their virtual reality environments. To keep company accountable, make sure that company can recycle e-waste and buy used electronics. Although large companies are responsible for the impact their actions have on the environment, it's also up to individuals to play their part. The metaverse has the potential to enhance sustainability in several ways. It can be used to assess and optimize sustainability goals prior to their occurrence, to enable individuals and organizations to work together in real-time and 3D to find solutions to sustainability issues, and to provide users with access to information from diverse fields all within one platform.

The metaverse can also be used to raise awareness of sustainability issues and improve efficiency in addressing them. Sustainability can be addressed through this meta ecosystem through virtual reality, and the metaverse can be used to bring together experts from various countries to find solutions to environmental issues. However, there are still some limitations to the metaverse's sustainability potential, such as its lack of widespread use and its reliance on bandwidth and electricity. With that said, the metaverse has the potential to be a sustainable framework that supports meta-performance and sustainability.

Here are some of the specific benefits of the metaverse for sustainability:

- It can help to reduce travel emissions by allowing people to meet virtually.
- It can provide access to information and data that would otherwise be difficult to obtain, which can help people to make more informed decisions about sustainability.
- It can help to raise awareness of sustainability issues and the importance of acting.
- It can be used to simulate and test sustainability solutions before they are implemented in the real world.

Overall, the metaverse has the potential to be a powerful tool for sustainability. However, it is important to carefully consider the environmental impact of the metaverse before it is widely adopted.

The metaverse has the potential to help achieve various goals of the 2030 Agenda for Sustainable Development set by the United Nations.

- Ending hunger and poverty: The metaverse can help to foster collaboration between different stakeholders, such as private and public sector actors, to achieve these goals. It can also help to enhance the standard of living for people all around the world by increasing productivity within various sectors.
- Enhancing the standard of living: The metaverse can help to enhance the standard of living for people all around the world by increasing productivity within various sectors, such as manufacturing, agriculture, and service industries. It can also foster the development of new initiatives that can contribute to sustainable growth.
- Sustainability: The metaverse can help to address environmental factors by providing a platform for data collection and analysis. It can also help to promote social inclusion by providing a space for people from all walks of life to connect and collaborate.

Here are some specific examples of how the metaverse can be used to achieve sustainable development goals:

- Virtual supply chains: The metaverse can be used to create virtual supply chains that can help to reduce the environmental impact of transportation.
- Telework: The metaverse can be used to facilitate telework, which can help to reduce commuting emissions.
- Education: The metaverse can be used to provide educational opportunities to people in remote areas, which can help to reduce poverty and inequality.
- Healthcare: The metaverse can be used to provide healthcare services to people in remote areas, which can help to improve health outcomes.
- Sustainable tourism: The metaverse can be used to promote sustainable tourism by providing virtual experiences that allow people to explore different cultures and ecosystems without having to travel.

The metaverse has the potential to be a powerful tool for achieving sustainable development. However, it is important to carefully consider the environmental impact of the metaverse before it is widely adopted. Metaverses help improve the knowledge base and disseminate information about economic development by measuring the progress against specific targets. By facilitating more flexible work arrangements, metaverses can help enhance the overall satisfaction of employees and business owners. Equal pay for equal work is one of the most important benefits that metaverses can provide. Working remotely or through virtual supply chains can allow employees to work from anywhere in the world without losing their salary. Educational resources and information relevant to sustainable development can be accessed through metaverses, which is a fundamental component of the common good. Using eco-design principles, which involve the use of sustainable practices in the production and distribution of goods, metaverse can help promote the efficiency of their operations. This can help minimize environmental impact.

The metaverse can be used to address the challenges of climate change and sustainability in several ways.

- Education: The metaverse can be used to educate people about the risks of climate change and sustainability. This can be done through virtual simulations, interactive exhibits, and other educational tools.
- Communication: The metaverse can be used to facilitate communication between different stakeholders, such as governments, businesses, and individuals. This can help to build consensus on climate change and sustainability solutions.
- Collaboration: The metaverse can be used to facilitate collaboration between different stakeholders on climate change and sustainability projects. This can help to accelerate the development and implementation of solutions.
- Simulation: The metaverse can be used to simulate the effects of climate change and sustainability solutions. This can help to assess the potential impact of these solutions before they are implemented in the real world.
- Decision-making: The metaverse can be used to support decision-making on climate change and sustainability. This can be done by providing decision-makers with access to data, simulations, and other tools.

The metaverse is still in its early stages of development, but it has the potential to be a powerful tool for addressing the challenges of climate change and sustainability.

Here are some specific examples of how the metaverse can be used to address climate change and sustainability:

- Virtual simulations: The metaverse can be used to create virtual simulations of how climate change will affect different parts of the world. This can help people to understand the potential impacts of climate change and to develop adaptation strategies.

- Interactive exhibits: The metaverse can be used to create interactive exhibits that allow people to learn about climate change and sustainability in a fun and engaging way. These exhibits can be used in schools, museums, and other public spaces.
- Educational tools: The metaverse can be used to create educational tools that allow people to learn about climate change and sustainability at their own pace. These tools can be used in schools, online, and in other settings.
- Communication platforms: The metaverse can be used to create communication platforms that allow people to connect with each other and share information about climate change and sustainability. These platforms can be used to build community and to raise awareness of these issues.
- Collaboration platforms: The metaverse can be used to create collaboration platforms that allow people to work together on climate change and sustainability projects. These platforms can be used to accelerate the development and implementation of solutions.

The metaverse is a powerful tool that can be used to address the challenges of climate change and sustainability. However, it is important to use the metaverse responsibly and to ensure that it is used in a way that benefits the environment. Through the metaverse, people can gain a deeper understanding of how their actions can affect the environment. Through the metaverse, different disciplines, such as engineering, architecture, and urban planning, can be brought together. For instance, policy makers can gain an understanding of how traffic flows will be affected by the construction of new roads and buildings. Figure 1 represents the elements of the metaverse.

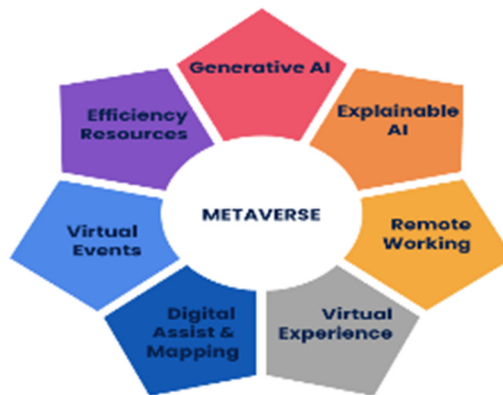


Figure 1: Metaverse

Source: Authors' own conception

Scientists can use the metaverse to improve their research by sharing information about creatures that live in extreme environments. It can also help them monitor changes in the world's environment. The concept of the metaverse refers to a world where actions are made and carried out according to the states of mind. It is reasonable to assume that the experiences that people have gained through the metaverse can have beneficial effects on the planet. A metaverse is an information space that can be used to visualize and understand complex AI systems. Structures within the metaverse can support driverless cars and drones. It also allows companies to cut down on greenhouse gas emissions by connecting e-commerce and social networks.

The integration of smart cities, the circular economy, and the metaverse will become a central theme of development in the future. The need for waste mitigation and technology will drive this trend (Aviles, 2021). One of the biggest issues that must be resolved is the energy consumption of

servers. Since the metaverse will need a lot of data storage and computation power, the need for more computing resources is expected to be a major issue. This is why it is important that the various aspects of the ecosystem are addressed to minimize the carbon footprint and improve the efficiency of the system. Through education, the public can be informed about the principles of the metaverse and encouraged to adopt sustainable practices. Simulations and virtual events can be used to highlight the advantages of recycling and minimizing waste. The metaverse can additionally be used to develop and implement strategies related to sustainable development goals. In different industries, the sharing of virtual resources can help reduce waste and extend the lifespan of products. Through the metaverse, the business can reach out to its employees and customers to promote sustainable practices. This can be done through virtual and interactive learning sessions that can help participants adopt new technologies and procedures.

5. Methods for Studying Circular Economy, Waste Management and Metaverse

Although the terms "Metaverse" and "Circular Economy" have very few records (Shishehgharkhaneh et al., 2022; Kanak et al., 2022), none of them tackled the topic of energy security or the waste management. Integrating waste management into the metaverse can help minimize the amount of physical waste by allowing businesses, education, and individuals to interact digitally (De Giovanni, 2023). Like the concept of circularity, education, and the transfer of knowledge about sustainable practices can help promote responsible behavior. Through simulation exercises, the public can learn how their everyday habits can affect the environment, economy, and society (Kar & Varsha, 2023). Using the metaverse, recycling and repurposing of materials and goods can be improved. This can help reduce the amount of waste by allowing businesses and individuals to interact digitally (Loizia et al., 2021). As a repository for information on various aspects of waste management, the metaverse can serve as a valuable tool for policymakers and public authorities. It can also help them develop effective urban or national strategies.

The study aimed to provide a comprehensive analysis of the circular economy and encourage the public to adopt sustainable practices. The study found that the metaverse can be used to educate the public about sustainable practices and simulate real-world situations to show how their actions can affect the environment and society. The study also found that the metaverse can be used to improve recycling and repurposing of materials and goods, which are often regarded as waste. The metaverse can also be used as a repository for information on various aspects of waste management, such as consumption patterns and the generation of waste. This information can be used to inform policymakers and public authorities about the viability of existing waste management strategies. The study concluded that the metaverse has the potential to be a powerful tool for promoting sustainability and waste management. However, more research is needed to explore the full potential of this technology.

The metaverse can be used to improve waste management by:

- Facilitating information sharing and communication among policymakers and waste management practitioners (Zawish et al., 2022).
- Allowing organizations and individuals to design processes and visualize complex operations (H. Lin et al., 2022).
- Hosting virtual gatherings, workshops, and meetings where people from different parts of the world can come together to discuss solid waste management issues and develop new strategies (Wiederhold, 2023).
- Providing users with new value by creating new experiences that are not possible in traditional environments.
- Collecting and analyzing data related to waste management practices.
- Implementing and testing various circular economy techniques.
- Analyzing and modeling different strategies related to waste management.

- Testing and refining approaches before implementing them in real life.
- Transforming how society views waste.

The metaverse is a new and emerging technology, and its full potential for waste management is still being explored (Ning et al., 2021). However, the potential benefits are significant, and the metaverse could play a major role in improving waste management practices in the future (Ning et al., 2023). Researchers of this study try to represent the whole concept in figure 2.

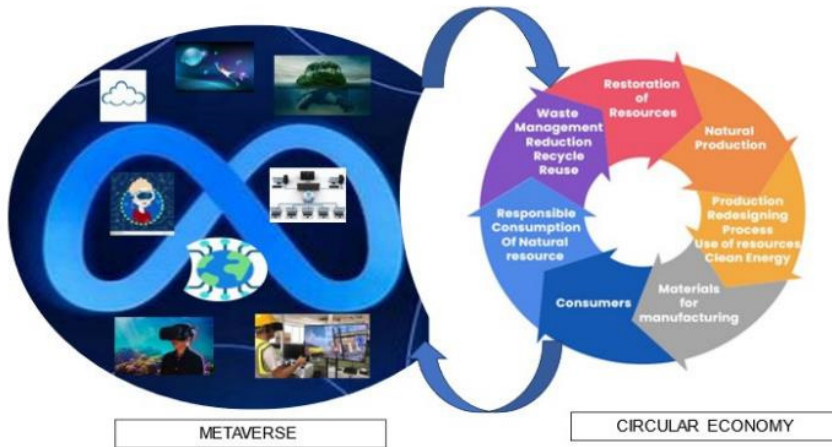


Figure 2:
Source: Authors' own conception

6. Challenges

The metaverse is a rapidly emerging technology that has the potential to revolutionize the way we live, work, and play. However, the metaverse also poses several challenges, including the potential for environmental impact (Das, 2023). Combining the metaverse with the circular economy principles presents numerous challenges and opportunities. One of the main challenges is translating sustainable practices from the physical world into the virtual realm (Das et al., 2022a). As we navigate this new digital landscape, we must ensure that our actions within the metaverse align with sustainability goals. It includes considering the environmental impact of digital infrastructure, such as data centres and energy consumption (Das et al., 2022b). Furthermore, fostering a culture of responsible consumption within the metaverse is essential. While virtual goods may not have a physical presence, they still have an environmental footprint (Di Virgilio and Das, 2023a). The production and disposal of digital assets can contribute to carbon emissions and resource depletion. Therefore, promoting sustainable behaviours and encouraging users to make conscious choices when creating, purchasing, and disposing of virtual goods is crucial (Di Virgilio and Das, 2023b).

Digital marketplaces within the metaverse can play a significant role in advancing the circular economy. These platforms can facilitate the exchange and reuse of virtual assets, reducing the need for constant production and consumption (Duy et al., 2020). By promoting second-hand markets and encouraging users to resell or trade their virtual possessions, we can extend the lifespan of digital goods and minimize waste (Majerova and Das, 2023a). Technologies like blockchain and virtual currencies also have the potential to drive sustainability within the metaverse. Blockchain technology can provide transparency and traceability, allowing users to verify the origins and lifecycle of virtual assets (Majerova and Das, 2023b). It can incentivize sustainable practices and discourage the creation

of environmentally harmful digital products (Minh-Nhat et al., 2022a). Virtual currencies, on the other hand, can be used to reward users for engaging in sustainable behaviours, such as recycling or participating in community initiatives (Minh-Nhat et al., 2022b).

Here are some of the challenges that need to be addressed to make the metaverse more sustainable:

- **Energy consumption:** The metaverse requires a significant amount of energy to power. This energy consumption can lead to greenhouse gas emissions, contributing to climate change (Mondal et al., 2023).
- **Waste:** The Metaverse could lead to increased consumerism, as people spend more time in the metaverse and buy more virtual goods and services. It could lead to increased waste, as these goods and services are often discarded quickly (Mondal and Das, 2023a).
- **Material use:** The Metaverse requires significant materials to build and maintain. These materials can come from unsustainable sources, and their extraction and processing can have a negative impact on the environment (Mondal and Das, 2023b).
- **Lack of awareness and understanding:** Many businesses and consumers are not aware of the metaverse or its potential for the circular economy (Bassi et al., 2020).
- **Cost of implementation:** The cost of implementing and using the metaverse can be high, especially for small and medium-sized businesses.
- **Technological limitations:** The metaverse is still under development, and there are some technological limitations that need to be addressed, such as scalability and security (Chen et al., 2020).
- **Regulatory challenges:** There is a lack of clear regulation on the metaverse, which can create uncertainty for businesses and investors.
- **Ethical concerns:** There are several ethical concerns that need to be considered when implementing the metaverse, such as privacy, data security, and the potential for addiction.

7. Opportunities

The metaverse can serve as a valuable role model for the advancement of the circular economy by helping policymakers, companies, and individuals to accelerate the shift to a zero-waste world (Mondal and Das, 2023c). Through the metaverse, people can participate in a variety of circular innovations such as recycling stations that allow people to reuse their products and packaging and reward them with money for their efforts. This can change the way people think about the environment and how they behave in real life. Using circular opportunities, companies can create new business models that can attract new customers and foster loyalty (Ngoc-Vinh et al., 2022). The increasing number of direct-to-consumer brands that have partnered with non-fungible token (NFT) shows that there is a compelling case for the circular economy (Nguyen et al., 2022). Critics often say that policymakers are slow to adapt to new trends, but they can now test new ideas with minimal risk (Puri et al., 2023). This could help speed up the development of policies that would empower people to move faster.

Researchers must address the challenges and envision a future where the metaverse and the circular economy go hand in hand. It requires collaboration between technology developers, policymakers, and users to create a sustainable digital ecosystem (Tandon and Das, 2023). It also calls for education and awareness-raising to ensure that individuals understand the environmental implications of their actions within the virtual realm. So, combining the metaverse and the circular economy holds immense potential for revolutionizing our approach to consumption and sustainability (Tien-Dung et al., 2022a). By leveraging virtual platforms, digital marketplaces, and immersive experiences, we can reshape our understanding of sustainable practices and foster a culture of responsible consumption (Tien-Dung et al., 2022b). Technologies like blockchain and virtual currencies can further promote transparency and incentivize sustainable behaviours within

the metaverse. As we navigate the future, we must understand the challenges ahead and envision a future where virtual reality can catalyse positive change in our global pursuit of sustainability.

Imagine a world where people can work, play, and socialize in a virtual world that is free from the restrictions of real-world society. This would allow us to realize a circular economy. The activities that people perform in this virtual world require various types of virtual materials (Van et al., 2020). Researchers will explore what prevents the real-world from transitioning to a circular economy and how the metaverse can help facilitate this transition. The main attraction of virtual worlds is their absence of limitations. If, materials that can regenerate when they are mined at a scale, then there is absolutely no problem for anyone ever. If by any way people commit themselves to 100% recycling of their packaging and products after using them, then there will be absolute existence of circular economy in real sense (Vrana and Das, 2023a). Unfortunately, the case for the circular economy is not very compelling if the price of virgin materials remains the same as that of recycled materials. This is because the negative externalities of the former are not internalized by the latter. In addition, the government often subsidizes the procurement of virgin materials. This makes the sourcing of virgin goods and services unobjectionable in the metaverse. One of the main factors that prevents people from participating in the circular economy is the lack of diversity in the various circles that are currently engaged in discussion about the future of the planet (Vrana and Das, 2023b). This is because policies and institutions that are designed to maintain a certain level of exclusivity are not inclusive of everyone.

Here are some of the opportunities that the metaverse offers to help us transition to a circular economy:

- **Virtual marketplaces:** The Metaverse could create virtual marketplaces for used goods and services. It would help to reduce the amount of waste that is generated.
- **Virtual factories:** The Metaverse could be used to create virtual factories that are more efficient and sustainable than traditional factories. These factories could use 3D printing and other technologies to create more durable and longer-lasting products.
- **Shared ownership:** The metaverse concept could make transferring ownership of their services and goods easier. It would reduce the need for people to buy new things, and it would help to reduce waste.
- **Virtual product design and manufacturing:** The metaverse can be used to create virtual prototypes of products, which can then be tested and refined before they are physically manufactured. This can help to reduce waste and improve product quality (De Pascale et al., 2021).
- **Virtual supply chains:** The metaverse can be used to create virtual supply chains, which can help to improve efficiency and reduce the environmental impact of physical supply chains.
- **Product lifecycle management:** The metaverse can be used to track the lifecycle of products, from manufacturing to disposal (Kravchenko et al., 2020). This information can be used to improve the circularity of products and reduce waste.
- **Consumer education and engagement:** The metaverse can be used to educate consumers about the circular economy and encourage them to make more sustainable choices (Kristensen & Mosgaard, 2020). For example, consumers could use the metaverse to learn about the environmental impact of different products and services, or to find products that are made from recycled materials.

In addition to these specific opportunities, the metaverse also has the potential to create new and innovative ways to implement the circular economy (Moraga et al., 2019). For example, the metaverse could be used to create virtual marketplaces where consumers can buy and sell used goods, or to create virtual repair shops where consumers can get their products repaired instead of replacing them (Rossi et al., 2020). Overall, the metaverse has the potential to play a significant role in the transition to a circular economy (Sassanelli et al., 2019). By providing a platform for virtual product design, manufacturing, supply chain management, product lifecycle management, and

consumer education and engagement, the metaverse can help to reduce waste, improve efficiency, and create a more sustainable future (Vinante et al., 2021).

8. Implications

The metaverse is built on a foundation of digital infrastructure, which requires a significant amount of energy to power. This energy consumption can lead to greenhouse gas emissions, contributing to climate change. In addition, the metaverse could also lead to increased consumerism (Yegen and Das, 2023). As people spend more time in the metaverse, they may be more likely to buy virtual goods and services. It could lead to increased waste, as these goods and services are often discarded quickly. However, there are also implications for the metaverse to help us transition to a circular economy. A circular economy is an economic system that aims to eliminate waste and pollution. It does this by keeping products and materials in use for as long as possible and recycling and recovering materials at the end of their life. The metaverse could help us to achieve a circular economy in several ways. For example, it could create virtual marketplaces for used goods and services. It would help to reduce the amount of waste that is generated. In addition, the metaverse could be used to create virtual factories that are more efficient and sustainable than traditional factories. These factories could use 3D printing and other technologies to create more durable and longer-lasting products. Overall, the metaverse has the potential to both contribute to environmental problems and help us to transition to a circular economy. It is essential to carefully consider the environmental impact of the metaverse as it develops.

The future of the metaverse and the circular economy is uncertain. However, there is potential for these two technologies to work together to create a more sustainable future. The metaverse can revolutionize the circular economy by creating virtual platforms where users can buy, sell, and exchange second-hand or recycled goods, reducing waste and promoting sustainable consumption.

- a. Virtual marketplaces within the metaverse can facilitate the trading of digital assets, allowing users to monetize their creations and incentivizing the production of eco-friendly virtual goods, such as sustainable fashion or renewable energy solutions.
- b. The Metaverse can provide a platform for virtual conferences, meetings, and events, reducing the need for physical travel and its associated carbon emissions while enabling global collaboration and knowledge sharing.
- c. Virtual reality experiences in the metaverse can simulate real-world scenarios, allowing individuals and organizations to experiment with sustainable practices before implementing them in the physical world, minimizing potential risks and costs.
- d. By leveraging blockchain technology, the metaverse can enable transparent and traceable supply chains, ensuring that products are ethically sourced and produced, reducing environmental harm and social injustices.
- e. The Metaverse can host educational programs and simulations that raise awareness about the circular economy, teaching individuals and businesses how to adopt sustainable practices and encouraging responsible consumption.
- f. Virtual reality shopping experiences in the metaverse can provide personalized recommendations based on user's preferences and sustainability values, promoting conscious purchasing decisions, and reducing overconsumption.
- g. The Metaverse can serve as a platform for collaborative innovation, bringing together individuals and organizations from different sectors to develop sustainable solutions, such as waste management systems or energy-efficient technologies.
- h. Virtual currencies within the metaverse can incentivize users to participate in circular economy initiatives by rewarding them for recycling, upcycling, or sharing resources, fostering a culture of sustainability and environmental stewardship.
- i. The Metaverse can facilitate the sharing economy by connecting individuals who want to lend or rent their underutilized assets, such as tools or vehicles, promoting resource efficiency and reducing the need for excessive production.

9. Conclusion

The combination of the Metaverse and the circular economy holds immense potential for revolutionizing our approach to consumption and sustainability. Overcoming challenges such as translating sustainable practices, fostering responsible consumption, and addressing environmental implications is crucial. Technologies like blockchain and virtual currencies can further promote transparency and incentivize sustainable behaviors within the Metaverse. Collaboration between stakeholders is essential to create a sustainable digital ecosystem. As we navigate the future, it is crucial to envision a future where virtual reality can be a catalyst for positive change in our global pursuit of sustainability.

The rapid emergence and evolution of the circular economy and the metaverse have presented both exciting and challenging opportunities. The metaverse can serve as a platform for developing virtual economies that are focused on conserving resources and minimizing waste. However, it requires a significant amount of expertise, innovation, and cooperation to sustain and develop such systems. The security, privacy, and ownership of the data collected and stored in the metaverse will be among the most critical issues that need to be resolved in order to make the benefits of the circular economy and metaverse accessible to everyone. The success of the project will depend on the collective efforts of various parties, including governments, businesses, and individuals. The time has come for the various parties involved in the project to embrace and implement the technological advancements and knowledge transfer that will allow them to make the most of the opportunities presented by the metaverse.

Prominent challenges like privacy and security where the metaverse will collect a vast amount of data about users, including their location, activities, and interactions. This data must be secure and private to protect users' privacy. Secondly the ownership of data in the metaverse is also a complex issue. Who owns the data that is collected about users? Who has the right to use this data? These questions need to be answered to ensure that users' rights are protected. For sustainability challenge, the metaverse must be developed in a sustainable way. The energy consumption of the metaverse must be minimized, and the use of recycled materials must be maximized. Despite these challenges, the potential benefits of the metaverse for the circular economy are significant. The metaverse can help to conserve resources, minimize waste, and create a more sustainable future. The time has come for the various parties involved in the project to work together to make this vision a reality.

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