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The Metaverse as a Virtual Form of Smart Cities: Opportunities and Challenges for Environmental, Economic, and Social Sustainability in Urban Futures

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Abstract: Data infrastructures, economic processes, and governance models of digital platforms are increasingly pervading urban sectors and spheres of urban life. This phenomenon is known as platformization, which has in turn given rise to the phenomena of platform society, where platforms have permeated the core of urban societies. A recent manifestation of platformization is the Metaverse, a global platform project launched by Meta (formerly Facebook) as a globally operating platform company. The Metaverse represents an idea of a hypothetical "parallel virtual world" that incarnate ways of living and working in virtual cities as an alternative to smart cities of the future. Indeed, with emerging innovative technologies—such as Artificial Intelligence, Big Data, the IoT, and Digital Twins—providing rich datasets and advanced computational understandings of human behavior, the Metaverse has the potential to redefine city designing activities and service provisioning towards increasing urban efficiencies, accountabilities, and quality performance. However, there still remain ethical, human, social, and cultural concerns as to the Metaverse's influence upon the quality of human social interactions and its prospective scope in reconstructing the quality of urban life. This paper undertakes an upper-level literature review of the area of the Metaverse from a broader perspective. Further, it maps the emerging products and services of the Metaverse, and explores their potential contributions to smart cities with respect to their virtual incarnation, with a particular focus on the environmental, economic, and social goals of sustainability. This study may help urban policy makers to better understand the opportunities and implications of the Metaverse upon tech-mediated practices and applied urban agendas, as well as assess the positives and negatives of this techno-urban vision. This paper also offers thoughts regarding the argument that the Metaverse has disruptive and substantive effects on forms of reconstructing reality in an increasingly platformized urban society. This will hopefully stimulate prospective research and further critical perspectives on the topic.

Keywords: metaverse; smart cities; digital twins; future cities; forecasting; quality of life; urban policy; digital economy; climate change; virtual reality

1. Introduction

The concept of the Metaverse has been around for decades but has come to the public fore with the rebranding of 'Meta'. In announcing this rebranding, Meta, the 'Big Tech' company with currently the biggest stake in the Metaverse marketplace, signaled a significant pivot in its resources towards the development of virtual, augmented, and mixed realities. With other comparable digital companies pooling resources, it can be expected that our technological future will shape the way people globally and locally live, work, and entertain themselves in urban society. In the past decade, the world has been enveloped with groundbreaking innovations and technologies courtesy of the fourth industrial revolution, aided ironically by our COVID-19 home entrapments. Of the technologies that have been exponentially growing, the more prominent is virtual reality (VR) which has been aided by parallel advancements in AI, the IoT, Clouds of Things, Big Data, and other technologies. The adoption of digital technologies in different global spheres has gained substantial intangible territories in the recent past due to the onslaught of workplace and marketplace resilient responsiveness tactics to COVID-19. However, technological penetration had already been happening in cities well before COVID-19, via the pursuit of the smart city agenda [1].

While the COVID-19 pandemic has triggered new ways of working digitally across the globe, and VR/AR technologies offer a potentially effective solution [2], it has exacerbated issues of the increasing involvement of big data companies in data policy and data privacy through the accelerated adoption of big data technologies [3]. In addition, with this 'human-made crisis', as its protagonists boldly call it, the practical efficacy of these technologies, most of which have been used for dataveillance and geosurveillance (including biometric wearables, facial expression recognition, smartphone apps, smart helmets, and predictive analytics), have been questioned and challenged with respect to their ability to produce the intended results or their utility to tackle COVID-19 [4,5]. Indeed, with the practice of monitoring digital data pertaining to personal details and online activities as well as human movements, thanks to the rapid deployment of such technologies in major cities, we have all witnessed how our life passes under the watchful eye of the state and how easily our human and civil rights could be crushed under the guise of public health. For instance, the fine-grained tracking and tracing technologies used during the height of COVID-19, have, per a recent study [6], substantially led to a significant compromise of human rights and civil liberties. The authors of this study state 'that human rights offer a crucial framework for protecting the public from regulatory overreach by ensuring that digital health surveillance does not undermine fundamental features of democratic society'.

However, the Metaverse project was launched amid the COVID-19 pandemic, a crisis purported to be a rare opportunity that should be seized to reimagine the world, thereby increasing mistrust and skepticism of the idea of the Metaverse. As argued by Bibri and Allam [4], the "new normal" enforced during the COVID-19 pandemic has already set the stage for undemocratically resetting and unilaterally reimagining the world, resulting in an abrupt large-scale digital transformation of urban society that is in turn paving the way for a new era of merging urban life and virtual life. Due to these crises, a new normalcy has prompted major redefinitions in human interactions, work, travel, recreation, and communication. Meanwhile digital technologies have given an upper hand to enforcement agencies in their efforts to effect policies such as lockdowns and restricted movements, mostly in cities where interconnectedness is relatively more advanced. Furthermore, while recent developments, especially increases in connectivity hinged on current 5G connectivity speeds and anticipated 6G connectivity speeds, may play significant roles in helping actualize the Metaverse concept [7], these wireless networking technologies come with serious risks to human health and lethal consequences, as demonstrated by many experts in the field. For instance, in 2017, over 250 doctors and scientists, drawn from the European Union (EU), raised concerns about the health risks associated with 5G and called governments to impose a moratorium on the rollout of this technology [8]. This could explain why Zuckerberg [9] observed that the implementation of the Metaverse would require a substantive initial investment, in both financial and physical resources,

for it to be actualized. Further, with regards to financing, it is conceded that thousands of billion dollars have already been used by consumers of virtual digital products, especially in the gaming world where users purchase different digital accessories for their online 'avatars'. To put this in perspective, it is estimated that in 2020, the Extended Reality market was valued between USD$26 to USD$33 billion [10]. It is also anticipated that, following current commercial interests in this technology, by 2026 the consumer market could possibly grow to approximately USD$125.2 billion [11]. However, for the concept to be universally accepted by non-technologists availing its acceptance into disciplines including urban planning, huge financial and technological resources will need to be availed. As evidenced by Meta's shift to not only rebrand but to pivot its innovative attention to the actualization of the Metaverse concept, there will be a need for major paradigm shifts in our governance and policy structures to accept and enable this technological frontier.

Smart urbanism and platform urbanism are interrelated as approaches to urban development in that the latter originated in the multifaceted emergence of the former over the past two decades [12]. Generally, smart urbanism is understood as a model of urban development focused on the use of Big Data, digital flows, and networked technologies [13,14] regarding urban operational governance and urban services. These aspects of smart urbanism tend to capture the nature of platform urbanism as a manifestation of the practice and process of platformization. Ref. [15] defines platform urbanism as a "novel set of digitally enabled socio-technological assemblages rooted in the urban, which enables the emergence of new social and material relationships including intermediations and transactions". Platformization refers to "the penetration of infrastructures, economic processes, and governmental frameworks of digital platforms in different economic sectors and spheres of life, as well as the reorganization of cultural practices and imaginations around these platforms" [16]. Given its universal character, this phenomenon has in turn brought about the phenomenon of platform society, which involves intense struggles between government, market, and civil society as contesting societal actors that have competing ideological systems with respect to the responsibility for anchoring the common good and public values in a platform society, including in terms of privacy, safety, fairness, accessibility, accountability, and democratic control [16]. However, research and development of the Metaverse has become a key trend in smart urbanism in terms of the design of believably virtual cities based on large-scale data-driven AI systems. This relates to what has been termed "virtual urbanism" or "augmented urbanism" [17,18] with respect to the application of urban planning, urban design, and urban geography to the design of virtual and augmented urban spaces. Therefore, the key dimensions inherent in understanding the concept of the Metaverse, especially concerning its applicability in urban centers, are sourced from technical circles [19]. The latter include the increasing activities of data harvesting and modelling by urban planning practitioners to guide, inform, and envisage our urban places. Their activities include city and data mapping, aiding micro recalibrations in their policy determinations that help to understand and address existing and emerging issues in cities, especially with new planning models. These include the smart city concept (e.g., [20]), the '15-min city' concept [21], the 'data-driven sustainable smart city' concept [14], and others.

In light of the above, there is an increasing recognition that mastery of digital and computing technologies are particularly important as many urban societies and individual city economies are, in the shadow of their COVID-19 experiences, pivoting through the regrouping and re-strategizing of their economic and social visions. COVID-19 has dramatically changed city governance approaches to economic support packages and mechanisms, rebates and taxation 'treats', and medical, social and physical infrastructure, echoing the analogous policy responsiveness and legacy of the international 1918–1920 Spanish Flu. During and after this influenza pandemic, many nations crafted a 'nation-specific new normal' and the still to be charted 'global new-new normal' [22]. However, these narratives are associated with controversies. In a similar vein, the Metaverse can be understood as a fictional representation of urban worlds that convey future possibilities

and warning signals. Fictional representations can provide alternative views on how the future is being understood, shaped, and framed [23–26]. Salerno [27] has critically investigated how ICTs play a role in creating a new system of urban ideas and ideals from the new forms of their use and the imaginaries they produce. A recent study conducted by Bibri [28] extends social scientific critiques and understandings of the socio-technical imaginaries of smart cities based on the analysis and evaluation of the Metaverse as a set of fictional representations and the urban worlds it imagines and the warnings it animates in order to help the construction of alternative desirable urban futures.

Against the preceding background, this paper undertakes an upper-level literature review of the area of the Metaverse from a broader perspective. Further, it maps the emerging products and services of the Metaverse, and explores its potential contributions to smart cities with respect to their virtual incarnation, with a particular focus on the environmental, economic, and social goals of sustainability.

This paper unfolds as follows: Section 2 covers the origins, definitions, characteristics, partnerships, forecasting, and related work of the Metaverse. Section 3 maps the products and services of the Metaverse as introduced by Meta, Section 4 delves into the potential contributions of the Metaverse to the goals of sustainability. This paper ends, in Section 5, with a discussion and conclusion [29–36].

2. The Metaverse: A Broader Perspective

2.1. A Brief History

Historically, the term 'Metaverse' was introduced to the world in 1992 by Neal Stephenson in his science fiction novel Snow Crash [37]. In Snow Crash, Stephenson envisioned people escaping the harsh reality of a collapsed economy that had befallen the world, into a digital virtual reality environment. This echoes the appropriation of future sciences with contemporary histories, as successfully advanced by Isaac Asimov (1920–1992), Arthur C Clarke (1917–2008), Ray Bradbury (1920–2012), HG Wells (1866–1946), Jules Verne (1828–1905), and even the classic comic science fiction of the Hanna-Barbera invented The Jetsons (1962–1963) (with its elaborate robotic contraptions, aliens, holograms, and whimsical inventions). Stephenson's novels include a number of concepts and ideas such as having 'headsets' and 'goggles' that allowed people to immerse into a fictional pre-VR world before goggles and technologies—pushing the global market for these products toward profitable paths. These concepts relate particularly to the idea of 'Extended Reality' (XR) coined by Paul Milgram (a universal term for immersive technologies including Augmented Reality (AR), Mixed Reality (MR), Virtual Reality (VR), 360, and others).

That said, the Metaverse concept has experienced some limitations hampered by its inability to obtain market acceptance in consumer circles, despite gaining considerable attention in discrete fields such as online gaming and amongst tech enthusiasts. As an example, the idea of virtual reality advanced in Stephenson's book [37] did not gain instant acceptance in consumer circles. Thus, while Stephenson's VR did not capture the market attention and marketability interest of major product developers, it has been touted by several proponents as offering real potential in urban planning circles, entertainment spheres, and digital business worlds, attracting the attention of 'big players' including Meta, Microsoft, and others that have shown interest in its prospective frontiers.

2.2. Definitions

The 'Metaverse' is an inspirational or a hypothetical term for a futurist digital world that, as depicted by its creators and advocates, is immersive and feels tangibly connected to the everyday objects and to the real lives and bodies of humans [19]. As narrated by Zuckerberg, it will be built by Facebook in collaboration with not only experts and industry partners, but also policymakers, institutions, and other organizations. A real-time 3D network of virtual worlds and augmented realities will characterize the hypothetical iteration of the internet. Such a new world will be anchored within the convergence

intersection of physical, virtual, and augmented realities that share online spaces in a 3-D format, representing people, places, and things [38]. In such a space a human 'will be able to create and explore with other people who are not in the same physical space as you. You will be able to hang out with friends, work, play, learn, shop, create, and more' [6,13].

While this concept has been present in contemporary digital 'history' via the tenets of the concept of 'Extended Reality', global attention to and recognition of it occurred with the corporate rebranding of Facebook to 'Meta'. This speculated human perception shift is affirmed in Figure 1 (below, sourced from Google Trends) that depicts an analysis of news sources between January 2008 and November 2021 [39]. Figure 1 demonstrates that the term 'Metaverse' was little noticed until 2021, when public relations information about Facebook's rebranding and its Metaverse concept presentation started to trickle around the global community. Before the rebranding of Facebook to Meta, the idea of the Metaverse existed only as a science fiction narrative or a discrete conventional concept within digital technology disciplines. However, Zuckerberg's announcement about his plans for the big tech company to focus on this frontier reignited interest in this topic.

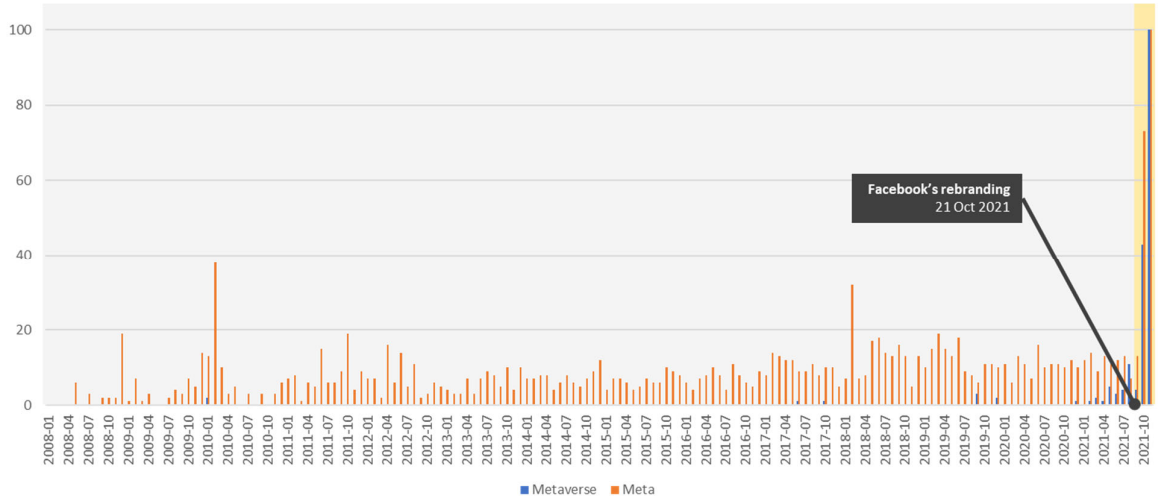

Figure 1. Rising popularity of the terms 'Meta' and 'Metaverse' terms since 'Facebook's rebranding and concept presentation. Sourced from Google Trends [9]. Illustration by Authors.

In particular, a parallel, exponential interest in the concept has been noted from other tech companies such as Microsoft [40], Apple [41], Magic Leap [42], and Roblox [43]; as if they are trying to pivot themselves and respond to what they perceived as a market change in technological niches, each individually announcing their own plans for pursuing their own forms of the Metaverse. On this, it is appreciated that most companies now seeking to explore the possibility of the Metaverse have been involved in games development, where they used the same concept to test different technologies. For instance, The Sims, in 2000 and Second Life, in 2003. Nowadays, games such as Roblox and Fortnite already allow players to interact with the entire world through customizable avatars, and this is important as it gives a glimpse of what to expect in the Metaverse.

2.3. Characteristics

In recognizing this trend, we also appreciate that the full actualization of the Metaverse concept will require concerted efforts and collaborations between different big tech companies [44], since the project is complex, expensive, and still new in its frontiers. In late 2021, Facebook announced additional global partners from industry, governments, non-profit organizations, academic institutions, and civil rights groups, to collaboratively build the Metaverse [45]. These include Colorintech (UK), Alte Nationalgalerie (Germany), and the Peres Center for Peace and Innovation (Israel), in addition to other institutions across the

globe, such as: Seoul National University; the University of Hong Kong; the Centre for Technology, Robotics, Artificial Intelligence and the Law (TRAIL) at the National University of Singapore; and Howard University, to facilitate independent external research.

In addition to collaboration, we argue that the primary factor towards the actualization of the Metaverse concept will prompt attempts to bridge societal and technological components [46]. On this, there have been some existing components, such as virtual reality (VR) headsets, which are observed to be popular with online gamers, enthusiasts, and hobbyists. However, the idea of the Metaverse, as expressed by Zuckerberg [47], has widened the scope of VR and augmented reality (AR) to include workplaces, entertainment, social interactions, creativity, and others. Thus, such parallel activities and diversions need to be integrated into the larger research journey, whereby the evolution of these physical products will ensure more individuals and groups are attracted to the anticipated digital world. Thus, the advanced nature and ease of accessibility of these digital 'tools' and 'toys' may prompt their ready acceptance and adoption into the community. The big tech companies who are already pursuing the actualization of the concept will need to, therefore, first engage with the targeted market through the introduction of physical products. These products include headsets and other hardware that serve as the gateway to the future digital world [48].

We recognize that a core aim of Metaverse is to build the next wave computing platform that convenes several sub-platforms accessible through the same digital space. However, the endeavor to achieve this aim, across virtual and augmented realities, is expected to deepen human connectivity dependencies upon idiosyncratic service experiences regardless of physical distance. Thus, while users are not expressing any desire for extraordinary in-service encounters, at least in the medium term, such signals—not to be too complacent—are envisioned to be desirable, pleasant, and entertaining to these users.

This idea is not new for big tech companies. Rather, some of these, such as Apple, have already selected 'keystone' stores or venues where they showcase their products [49]. Similarly, even Meta has had occasional pop-up stores in strategic places where some of its products, including the Oculus Quest VR were showcased. Others such as Google and Apple use their apps stores where most of their digital products are accessible, as well as many from third party developers [48]. As explained by Isaac [33], Meta is contemplating opening physical stores to allow its over 3.5 billion users to tangibly interact ('play') with components such as its Oculus headset and other hardware such as smart sunglasses. Further, Meta is already engaging with other companies (for instance Ray-Ban) in producing products popular with the broader society, by incorporating digital aspects. Through this marketing strategy, Meta is, arguably, attempting to actively engage with fashionista agendas by seeking to merge societal and technological components and interests slowly and gradually, and attempting to capture the photogenic capitalism market niche that is driven by self-promotion and self-isms.

Ref. [50] argues that another way of bridging this societal and technological world is to ensure that the Metaverse allows real-world activities, such as trade, work, recreation, and entertainment, to continue seamlessly. That is, the platform is strategically likely to ensure that companies and individuals have the market capacities to continue participating in different frontiers in the Metaverse environment comparable to their extant positions and activities in the physical world. Therefore, just as companies and individuals are able to make money and invest, there will be a need for non-fungible tokens (NFTs) in the Metaverse to allow users to claim ownership of their digital assets and products.

Extended-reality working environments support the need for a rich ecosystem contingent upon the active participation of multi-scale third-party developers. The participation of these developers would, in turn, spur demand for different digital products as well as help in producing different products to service community fashions and demands [19]. These third party developers would further help companies achieve the seven core attributes (persistence, synchronicity, interoperability, economic feasibility, content, experience, and the promise of an experience that allows extended reality and unlimited

opportunities) of Metaverse, as identified by [51]. In addition, the multiplicity of participants in the Metaverse development would help address the financial budgetary needs that have been identified as factors that will determine the success of this concept. This could be through collaboration or partnerships between different stakeholders.

2.4. Partnerships

Importantly, participation of different players will help build platforms and data exchanges pertinent to the success of the Metaverse. For instance, it will require concerted collaboration between different players to bring aboard different facets such as the use of 'avatars' (digital representation of oneself in the digital world), which will be almost inevitable in the virtual realm. The current tech-savvy generation that is inextricably carving up the English language into emojis is a reflection of the metaphorical doormat into this reality. Third-party participation will be key in this digital transformative journey as several have niche expertise in different frontiers, especially via virtual gaming platforms. Potential candidates here include companies offering online gaming services where gamers have the capacity to have their own digital representations (avatars) or urban modelling interactivity platforms. The essence of the avatar, in the case of the Metaverse, is noted to align with the aim to build a 'mirror world' (virtual 3D replica of the real world, or to explore new worlds) where users could have a 'digital twin' thereby bridging the digital and physical realities and creating unlimited possibilities [52]. For a detailed discussion on partnerships as well as interoperability and standardization in the context of the Metaverse, the interested reader might be directed to Bibri and Allam [4].

2.5. Forecasting the Metaverse as a Fictional Representation

The vision of the Metaverse is the result of technological forecasting, which involves generating a set of scenarios that corresponds to a future occurrence, i.e., how people will use the internet as a brain-like online infrastructure. These scenarios have been generated based on historical data and the outcome of the analysis of current trends as inputs to make informed predictions as to determining the direction of future trends of the internet and computing platforms. Forecasting concerns 'the extrapolation of developments toward the future and the exploration of achievements that can be realized through technology in the long term' [29]. Accordingly, the Metaverse emanates from a probabilistic prediction of technological changes in terms of the future features of AI, the IoT, and Big Data, and Digital Twins as a set of machines, systems, procedures, and techniques, as well as their role in advancing virtual worlds in an increasingly digitalized world. The Metaverse has been developed based on investigations of radical advances in science and technology, new social trends, and new forces which have arisen from the dynamic interplay of societal factors (Bibri 2022). Forecasts can be made on how soon some disruptive technologies or computing paradigms will be achievable and deployable and what characteristic features they may possess depending on various societal considerations. These are considered as external (non-technological) factors that are normally beyond the ambit of technology forecaster [31].

However, technologies remain unpredictable, regardless of the time horizon set for the vision where they may be expected to materialize. The Metaverse's products and services are expected to be fully realized in the next decade, at least as claimed by their proponents. This fact gives us time to elevate pertinent social and environmental critical issues and ask the difficult questions about how they will be built and delivered. Regardless, the limited presumptions of possible major change mean that technological forecasting fails to reach its goals [33]. A key problem that leads to faulty predictions is the inconsistency between forecasts in terms of their generation of inaccurate and unreliable data with respect to location and time [34]. Moreover, technological forecasting tends to present a more limited range of options, in addition to projecting current problems into the future [35] and neglecting and postponing the challenges of the present. In addition, past

forecasting studies have shown that ignoring the fields related to technological forecasting is one of the key reasons why forecasts go wrong [36].

Nonetheless, scholars have long explored fictional and imaginary representations of the city and urban life and how they shape and frame urban change [53–55]. In future studies, fictional worlds provide essential multidimensionality in imaginary ways of knowing, and making sense of them covers the institutional contours of imagined tomorrows [56]. Indeed, the idea of the smart city as a science fiction that was pictured in the popular media for much of the 20th century has become established in policy and planning discourse as visions of an urban future where advanced technology offers a panacea to the problems of the city. However, social-scientific literature is critically exploring how the imaginaries of the smart city promote techno-utopian fantasies, regarded "as emblematic of the colonization of contemporary (urban) futures by vested interests" [57]. Overall, the critique of fictional representations and socio-technical imaginaries of future urban worlds as techno-utopias invokes long-standing concerns about the impacts of scientific and technological advances on society.

2.6. A Short Survey of Related Work

Research in the Metaverse consists largely of two main strands. The first strand focuses on the technical aspects of the Metaverse in terms of technologies, applications, opportunities, developments, trends, challenges, open issues, agendas, conceptual frameworks, and so on (e.g., [2,58–61]. The second strand centers on the negative implications of the Metaverse (e.g., [4,62]. Bibri, Allam and Krogstie [35] have provided a detailed survey of extant work related to the Metaverse. Mystakidis [63] offers a comprehensive analysis of the extant literature, identifying current gaps or problems. Here, the author discusses a number of topics of the Metaverse as a multiuser environment merging physical reality with digital virtuality, including: extended, virtual, augmented, and mixed reality; multimodal Metaverse interactions; limitations of 2D learning environments; a brief history of virtual media and XR technologies; virtual worlds and virtual reality in education; and the contemporary development of the Metaverse.

3. Mapping the First Metaverse: Products of Meta

In mapping, we acknowledge that, despite numerous tech giants and other stakeholders now focusing their attention on the concept of the Metaverse, it is Meta that has taken a giant stride by proposing a number of interest areas that might become a reality in the future. On this, it is noted that companies such as Apple, Microsoft, and Google are also independently pursuing their own form of the Metaverse. Therefore, in the long run, our experiences and 'adventures' in all these platforms might help enhance the creation of a more profound Metaverse. In appreciating this context, this section explores a number of key products that Meta as a company is pursuing, recognizing that their intention is to slowly mold users' perceptions towards the new concept of the Metaverse. This intention is outlined below and is represented in Figure 2. This section, therefore, serves as a case study of select exemplars of products that might be available in the metaverse.

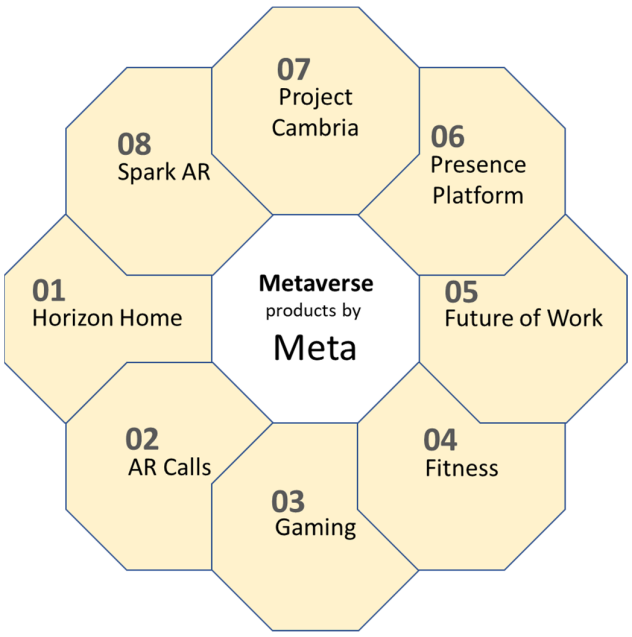

Figure 2. Products announced by Meta during its product launch. Illustration by Authors.

3.1. Horizon Home

Horizon Home was introduced as Meta's virtual reality social platform. Horizon Home seeks to provide users with unlimited capacities in their quest to connect and socialize with friends and families. The platform is fashioned whereby whoever 'enters' the digital environment via their digital product (currently the Meta's Oculus Quest 2), enters into a virtual 'home', where s/he has the opportunity to invite participants for different social events such as watching movies, gaming and many others [46]. Currently, as the concept is still new, the Horizon Home platform is being piloted and available virtual 'homes' are already scaffolded into the system [9]. However, it is anticipated that in the near future, after more research, development and feedback, users will be able to customize or personalize their virtual Horizon Homes in the Metaverse.

From a social perspective, the idea of Horizon Home offers opportunities for people to interact and socialize with friends from across the globe without economic and travel protocol limitations. From a critical perspective, this is intended to limit travelling and physical human interaction and other human needs that enrich social bonds and relationships, paving the way for more human rights and civil liberties to disappear under the new normalcy. However, the success of this platform is indeed said to have significant impacts in helping people maintain social interactions (though virtually) even amid the changing social environments prompted by uncertainties such as the current global COVID-19 pandemic. On the economic front, this platform is anticipated to spur unprecedented economic prospects both physically and digitally. Physically, the economic prospects will be in the form of sales of products including hardware and software that will support and allow users to connect [64,65]. Digitally, though it is still in its infancy, there could be the prospect of selling digital products such as those required for customization of homes, and the sale of digital entertainment products such as movies and many others [65]. In the technological sphere, this concept is expected to present new and complex opportunities for developers and numerous stakeholders as they interlace different designs, research, tools and other technology components to make a project a success. This would, however, demand substantial time and financial investments, but as there is an expected market for the product, it is expected that this segment will be popular amongst developers competing to offer better products.

3.2. AR calls

Starting February 2021, Facebook added Messenger APP to the Oculus Quest platform, allowing users who logged into the platform via their Facebook accounts to have the ability to chat using text messages even with the headset on [66]. COVID-19 quickly conditioned us to promptly take up Zoom or Teams software, so Messenger is a simple add-on. After its rebranding to Meta, the company introduced Messenger calls in VR allowing users to make audio calls on any Messenger platforms supported in the Metaverse [46]. Zuckerberg has argued that this new development would be welcomed by a larger audience, especially through the immersive experience in platforms such as Horizon Home, particularly when users can invite and interact with friends and family globally [9]. Further, with the use of Meta's Smart Glasses that were developed after a partnership with the Ray Ban Glass Company [67], it will be possible for users to make AR calls whilst wearing this less-obtrusive product making activities such as remote working (including servicing the hands-free context to advance universal design accessibility) a more feasible and richer experience in the Metaverse.

From a social aspect, allowing for video and holographic calls in the Metaverse will have positive impacts on actualizing interaction objectives. Despite notable social challenges, such as privacy concerns that need to be addressed (and that have already been raised about the social and privacy intrusiveness of Meta Ray Ban glasses), the collaboration between different developers is expected to overcome such social issues or to rechart a shift in the legal privacy discourses. Hence, there is a need to provide users with the possibility of customizing their virtual spaces recognizing that the whole concept of the Metaverse is about the cessation of privacy in its various forms, including mental, behavioral, and personal.

On the economic front, AR-increased telecommunication capacities may prompt an increased demand for products such as AR glasses as people seek to maximize their virtual reality experience. As a result, the market value for AR glasses is projected to grow from the current estimated market value of USD$7 billion to a high of USD$157 billion by 2030 [68]. While an AR call platform has added advantages compared with AR Messenger, it presents several major challenges as to ethics and privacy, especially as users juggle between their social accounts and work accounts, and must respect the human contexts that such technologies are used within in real-time, tangible environments. However, as expressed by Zuckerberg, developers will look towards how individuals could be offered options to create work and/or business accounts, where they can login whenever they are officially on work, thereby supposedly limiting disruptions from other virtual environment users. Though solutions proposed by the creators of technological visions always look feasible and easy at the discursive level, reality tells a different story at the practical level.

3.3. Gaming

Online gaming in virtual reality platforms has been in existence for decades, especially with the gradual increase in the popularity of VR products, including headsets. In the Metaverse, gaming platforms are expected to experience even further advancement, especially with the introduction of features such as Horizon Home and AR Calls. During Meta's Connect meeting of 2021 [9], Zuckerberg explained how the Metaverse would provide gamers with a platform that would increase their gaming experiences and allow more games to be included. It would also provide them with the potential to make substantial financial gains. The financial aspect, as noted by [69], would be spurred by increasing activities in the cryptocurrency markets, where prospects of earning digital tokens (non-fungible tokens—NFTs) from playing video games, that could be converted into real money, is attracting more players [70]. In addition to financial earnings, gaming in the Metaverse is touted to present opportunities to developers, creators, and players with a space to shape creative environments with new interactive possibilities not previously possible.

The success of the Metaverse could open up extra income streams, with unlimited economic opportunities for developers, investors, and business and game enthusiasts,

among other stakeholders. For instance, there are possibilities in gaming whereby virtual platforms will also offer opportunities for people to not only play and earn NFTs, but also to interact, learn, innovate and explore new adventures. The new income streams made possible by the Metaverse might have some positive bearing in overcoming social challenges, such as unemployment, that are synonymous with many global economies, especially in a post-pandemic arena.

Indirectly, gaming is integral to the electronic gambling marketplace, and thus corporations including Aristocrat Leisure, IGT, and Bally Technologies have already shifted their market platforms to capture this emerging niche.

3.4. Fitness

The emergence of virtual reality platforms has changed the way people exercise and undertake their fitness objectives. Such new tools are currently abundant in the United States, Canadian, and Australian television commercials. It has been reported that within the first quarter of 2021, over 700 million people subscribed to virtual gyms via VR [9], more so due to the unlimited number of customizable fitness packages available, aided by the inability to tangibly access gyms due to the pandemic. While VR 'gyms' have, in many cases, supplemented old gym routines, it is evident that this new platform holds key potential to almost completely replace the traditional gym venue as commonly known. This is being facilitated by the increasing number of new sets of accessories and exercise packages (dubbed Active Packs) that companies such as Meta are promising to introduce via its Oculus Quest 2 [9]. In the Metaverse, with a new package, the Meta is promising users an unmatched experience with accessories, including new grips and exercise-optimized facial interfaces that would allow individuals to control, customize and set new targets for their exercise programs.

Coupling this technology with others, such as Horizon Home, will allow users to invite friends for virtual group exercise programs, thereby promoting virtual social interactions and play. This would have positive impacts on helping overcome challenges that are already reported with online gyms, such as a lower satisfaction that has been prompting people to return to in-gym activities [71]. In the Metaverse, the experience will be immersive and is envisaged to mirror in-gym activities hindering the urge to return to traditional gyms as people continue to remain exercise-healthy while observing health protocols. In the economic spheres, the concept of fitness in the Metaverse is projected to hold unmetered opportunities. For instance, when Meta announced the Metaverse concept and its range of new products, existing fitness firms such as OliveX from Hong Kong were already reaping economic benefits with investors and shareholders injecting new financial supports [47]. For instance, in October 2021, the OliveX Company received a commitment of approximately USD$1,700,000 to boost its Metaverse presence [47].

On the technology front, the Metaverse presents developers, designers, and other stakeholders with opportunities to experiment and build fitness products that are both customizable and aligned with the objectives to sustain positive financial returns.

3.5. Future of Work

In addition to emphasizing social interactions, entertainment, fitness, and play, the Metaverse platform is also being designed to ensure that it opens an opportunity for global communities to work virtually, comparable with our current use of mobile phones and laptops [46]. The platform promises to be versatile, allowing users to work remotely, just as in physical offices (or rather the old-normal open-plan mass office environments). Within the Metaverse, users will manage to access different tools such as productivity apps, access Horizon Workrooms and Gravity Sketch, and access chat platforms to communicate and collaborate with colleagues. Further, the platform will allow users to access other services, including third-party mobile device management, account management and others [40].

The platform further ensures that users of digital products, such as Oculus Quest, will not need to log in to their personal computers but can access all their files and documents within the headsets. Socially, this will allow them to save time spent travelling and walking from different workplaces, offering increased workplace venue flexibility so that they can concentrate on work whilst having ample time to interact with friends and do other things they like when they like. An unknown trend will be whether these technologies will continue with their work on digital homes such as Horizon Home or shift to Horizon Workrooms. This could provide workers with maximum control over their work environment, enabling them the capacity to personally customize their work environment accordingly and it will be interesting to see how big tech companies like Meta, who have committed to continue updating their products to give workers access to a more diverse set of products, will pivot to enable and service this prospective trend [38].

3.6. Presence Platform

The Presence Platform, as described by Meta, is a group of machine perceptions and artificial intelligence (AI) capabilities that encompass tools (including Passthrough, Spatial Anchors, and Scene Understanding) made available to developers to allow them to design and build more advanced products. In particular, Meta's objective is to help developers to produce realistic mixed realities, interactions, and voice experiences for the Metaverse, to ensure that there is an extended reality between the virtual and the physical world. Thus, they aim to make the virtual environment feel natural and authentic [72]. Their objective in including these tools is to ensure that users have an immersive experience in the Metaverse and can feel as though they are still in the physical world. These tools are classified into three sets; Insight Software Development Kit (SDK), Interaction SDK, and Voice SDK [72].

The importance of this platform is to ensure developers have at the tools at their disposal to allow them to make other components of the Metaverse, such as the Horizon Home, Horizon Workplace, Horizon Venue, and others, truly immersive with controls such as voice commands. While it is acknowledged that it would take time for the Metaverse to be realized, this platform enables users of Oculus to gradually experience what the Metaverse will entail. In respect to this technology, while many new building blocks will be required, the Presence Platform provides an opportunity for available technologies such as virtual reality and mixed reality to be exploited as more technologies are developed and incorporated. Therefore, as foreshadowed by Zuckerberg during his 2021 connect meeting [9], this will be evident when the Meta Company launches Project Cambria in 2022.

3.7. Project Cambria

Project Cambria is envisioned to be a high-end virtual reality and augmented reality hybrid headset. While most of the new concepts and platforms that represent Meta's Metaverse are accessible via the company's headset (Oculus Quest), the company has been working on another project dubbed Project Cambria. This project is expected to yield high-end VR devices that will encompass all the latest advanced technologies the company is creating and incorporate existing ones, including Horizon Home and Horizon Workplace [47]. As noted above, Project Cambria is expected to give life and more impetus to the Presence Platform as it will accommodate all the tools and technologies that developers, designers, and creators for Metaverse will require. In other words, Project Cambria is expected to include capabilities that are not possible with VR headsets currently available in the marketplace. It is expected to provide virtual avatars with capabilities like maintaining eye contact as well as reflecting some of the facial expressions of the real person [73]. This will allow people to interact more naturally in the virtual environment. Project Cambria will also allow its users to experience and view objects found in the physical world in a more realistic way by presenting a sense of depth and perspective. In this way, users will have a more advanced immersive experience, previously unexperienced with other hardware.

While Project Cambria promises a wide array of opportunities for social activities, the resulting headset is projected to be relatively more expensive than other headsets such as Oculus Quest 2 and AR glasses. But its advanced features will probably attract more users. Thus, the economically stratified market growth can be foreseen. This will be possible as the company is also partnering with third-party developers who can help increase competition and lead to lower associated and productivity costs for access to technology and products.

3.8. Spark AR

Spark AR is Meta's Hub that allows different Artificial Reality effects creators and developers to publish, manage and track the impacts and performances of these products in different mobile apps and devices of the company [9]. Unlike other hubs, Spark AR is available for all Meta's account holders and has tools and accessories for all individuals, despite their programming, development, or creation backgrounds. Thus, the hub allows everyone to create their own effects and publicize them on any of Meta's different social platforms. As a result, it is reported that over 700 million effects are shared each month by different users, and these are expected to increase exponentially with the launch of the Metaverse [9]. Indeed, we argue that the Spark AR Hub will play a key role in populating the Metaverse environment with content and experiences that will allow different digital platforms to offer a wide range of social experiences that will not only delight, but also inform. This will be further influenced by the increasing attention on the company to offer more digital tools that will allow Spark AR creators to experiment with extended reality where they present digital objects into the physical world in a realistic way.

With new tools and accessories available for developers and creators, the company has signaled interest in creating opportunities through Spark AR that will allow creators to earn and make a living by building AR effects. Within the Metaverse, the aspect of promoting and sharing AR Effects will be more extensive and immersive than with current AR headsets, due to the ability to seamlessly fuse physical and virtual realities. This ubiquity allows more people to interact with them, and with the help of other platforms available in the Metaverse, it will be possible for creators to interact with those interested in their works and create richer interactions and products.

4. The Metaverse and Its Opportunities for Future Smart Cities

4.1. The Metaverse and Digital Twins

Digital Twins (DT) technology can be described as a computer program that allows for the representation of digital replicas of physical objects, processes, or services in the digital world. The essence of this process is to enable the collection of data that help in the creation of simulations to model, test, and predict how a given product, process, or service would perform in the real world [74]. Through this technology, companies, firms, businesses, and other institutions will have the capacity to address 'what-if' scenarios termed 'modelling' in the application and discipline of urban planning discipline, for which Bibri [14,50] provides a descriptive account. Thus, they could provide customers and users of such products and/or services with the best solution, and also digital city models to assess capacity and offer immediate real-time visual representations of development scenarios or interventions. This offers the users of this technology benefits from reduced costs of testing and modelling, which are relatively expensive and/or labor-intensive and require considerable time to implement.

While DT technology provides unlimited potential for organizations, it is argued that the Metaverse will allow DTs to be recreated with live data, thereby allowing for realistic simulations/modelling of products or processes/cities or landscapes just like they would, to some extent, behave in the physical world. This would further allow potential customers and the community generally to interact with products or prospective developments in the digital environment as they would occur in the real world thereby increasing human experience and providing more accurate qualitative and quantitative community engagement as

well as insights that enhance final products or processes/cities or landscapes [75]. By allowing for real-time interaction, the Metaverse platform will further help DT technology to overcome barriers such as limitations in storage, processing, and updating capabilities of maps in real-time. This will be overcome as it will be possible to permanently store a digital replica of a physical object in the Metaverse such that it could be accessed anytime.

In cities, the concept of DT, especially within the context of the Metaverse will have unprecedented impacts on simulating and modelling events such as floods, bushfires, energy demands in view of changing urban population, traffic movements, climate change variables, and other pertinent concerns for the urban planning discipline. By creating a DT (in 3D format) of a city, or a landscape, it will be possible to predict the effects of different issues such as climate, traffic dynamics, energy production and consumption, among others, before they occur. This is the next generation of geographic information systems (GIS) modelling [76], underpinned by Ian McHarg's ecological determinism [77], but in a more robust visualization context far more advanced than that offered by CommunityViz today [78]. Such prediction tools will inform decision-making about how to avert most negative impacts on urban activities and shift policy concentration upon the positive aspects.

There are already prospects of cities adopting DT technology to allow for real-time responses to different challenges affecting urban physical assets. For example [79] reports that cities such as Orlando, Las Vegas, and Boston already have their virtual replicas, allowing local governments to anticipate and address different scenarios such as proposed land use, and impacts of new streets, among others. Such efforts could be positively complemented by the Metaverse where urban planners, developers, administrators, and other stakeholders will have equal opportunities to interact and collaborate within the digital realm as they make plans and seek solutions for various urban issues. For instance, regarding climate change, which is a major urban issue, the DT technology in the Metaverse will allow for both the prediction of such events as flooding as well as modelling prospective scenarios and this can inform infrastructure planning and emergency risk responses preparedness; however, this is our thought and not one that is outlined in the current Metaverse literature. Most importantly, the Metaverse could play a critical role in the reduction of emissions from sectors such transportation, manufacturing, and energy generation.

In fact, there are possibilities that the Metaverse will be powered by renewable energy sources, given that most companies that are advocates of this concept are either in the advanced stages of transitioning or on the pathway to achieving carbon neutrality. This remains to be further investigated at the practical level. For instance, Meta has committed to transition fully to renewable energy and have net zero emissions by the year 2030 [80]. Likewise, Microsoft, which is also leading in exploring the possibilities of the Metaverse (the company has pledged over USD$70 billion to develop games and software to be accessed via Metaverse) is also targeting carbon neutrality by 2030 [81]. Projected transitions are easy to make, as by the time the environmental targets are not reached, they will, as experiences have shown, be simply adjusted, and new targets are set again. Alternatively, a failure to reach previous targets will be justified by other external factors, or new priorities are set to increase financial performance instead of committing to environmental performance.

The DT technology will help in changing the target bases and in redesigning networks and activities to ensure that they align with the agenda of reducing emissions. In particular such objectives will be achieved as this technology will enable companies to increase their efficiency in operations and address areas or phases within their operations that are energy-intensive and prone to increasing emissions. For instance, adopting the work-from-home concept enabled by the use of extended reality allows workers to continue to use their home office, something which has appeared to become an environmental psychological conditioning response to COVID-19 lockdowns and our self-refuges.

4.2. The Metaverse and Urban Resource Management

The concept of resource management has been a critical factor in the natural resource management and urban planning disciplines for many decades. With the projected global urban population increase, the aspect of resource management will become even more pronounced. This is particularly affirmed by research findings that highlight that urban areas are responsible for the consumption of over 75% of global resources and also contribute substantially to environmental degradation through a raft of pollutions [82]. Other resources, such as land, water, fisheries, minerals, and forests will continue to become scarce as more people settle into urban areas. Therefore, urbanization (especially the trends of tree-change, sea-change and regionalization) will increase the intensity of consumption and depletion of these ecological assets, without giving room to the natural-based solutions to compensate for the lost resources. As a result, these challenges will continue to persist unless conclusive urban resource management practices are adopted [83]. On this, the concept of the Metaverse, as narrated by Zuckerberg [9], has the potential to influence positive resource management practices, especially through a disruption of the future of urban activities such as work, entertainment, recreation, travel, and others.

It has widely been argued that the realization of the Metaverse will greatly reduce the need for travel, especially to workplaces, entertainment venues, facilities, and others. This is because people will have opportunities to work, exercise, learn, play, conduct meetings, attend social events, and more in digital environments that mirror their physical world. In part, this is already evident in our post-COVID reluctance to return to a mainstream urban office environment. Through extended realities, such as AR and AU, it has already been demonstrated that people will manage to interact, collaborate on projects, make telephone/Teams/Zoom calls, and participate in other 'normal' activities on digital platforms just as is the case in the physical world [9]. This will be critical, especially in reducing energy consumption by automobiles, as well as reducing the consumption of resources used in the construction of workplace infrastructures, extensive transport networks, and others that directly or indirectly support the work environment.

With people spending much of their time in the virtual world and operating—due to the ease of accessibility to technologies such as DT and Extended Reality technologies, and aided by faster and cheaper internet services—just as they would in the physical world, the extraction and consumption of resources is likely to be reduced. This will be influenced by reduced demands for assets, including office spaces, transport infrastructure, entertainment centers, and others. This will become apparent as most products such as office blocks, some energy-consuming gadgets such as entertainment units, and others will become less attractive and seldom used as their DTs will be available in the virtual environment. While there is research showcasing that the Metaverse will contribute to high energy consumption by users [84], especially in the facilitation of the services, including high-resolution imagery and rendering, that have increasingly come to characterize the digital realm, such consumptions may be offset by reduced consumption in places such as office blocks, entertainment centers, and traffic. Similarly, the same may also be offset by the increasing attention being directed to renewable energy options, with big tech companies such as Microsoft, Apple, and others committing to transitioning to renewable energy sources [84].

4.3. The Metaverse and Urban Governance

The prospect of the Metaverse is also being hailed by some, especially in relation to allowing for most social activities that necessitate the creation of resource-intensive products such as toys, games, and festival products, to be increasingly created and stored in the virtual world. According to [85] this will help reduce resource consumption and pollution, as most of these products, in their physical form, end up in landfills, water bodies and other sensitive ecosystems. Thereby, these have been negatively impacting on urban, aquatic, marine, and biodiverse environments and their non-human residents. With

substantial products being stored in virtual environments, requiring only little physical resource development, cities will have capacities to enhance assets such as green spaces, water bodies within urban areas, cultural heritage sites, and many others. Further, this will help in enhancing the adoption of diverse nature-based solutions to help restore areas that have already experienced massive impacts of excessive resource consumption.

According to [86], urban governance can be described as the sum total of the diverse ways individuals, institutions, and different urban stakeholders plan and manage the general affairs of a city. This has been identified to be sometimes complex and controversial, especially regarding the exercise of authority, resource distribution and allocation, and implementation of different agendas [87]. This has consequently prompted the need for unity of purpose to ensure that the set urban objectives and goals are achieved, and that evolving urban challenges are addressed comprehensively and at optimal cost, thereby echoing exactly what the United Nations is seeking with its 17 Sustainable Development Goals (SDGs) [88]. These regard ICT as a means to protect the environment, increase resource efficiency, upgrade legacy infrastructure, promote socio-economic development, and advance human knowledge [89].

Urban governance entails human decision-making that seeks to ensure that all the components and different dimensions that make up the urban fabric are working coherently and sustainably. Noting that urban areas comprise different aspects and variables, the Metaverse offers a timely platform for urban governance as this may allow for urban services and assets to be offered virtually. This could thereby increase their efficiency, increase trust and accountability as well as reduce the costs, bureaucracies, and bottlenecks that have been observed to derail or make urban service delivery time consuming.

An example of how the Metaverse could successfully impact urban governance is offered by Seoul, South Korea. The city is proposing to embrace the Metaverse concept by availing some public services and cultural products in a digital environment [90]. With the use of VR headsets or AR glasses, residents of Seoul will have immersive experiences as they virtually tour some of the city's assets including virtual social halls, museums, parks and make use of some government services like filing of civil complaints [91].

According to [92] the prospect of the Metaverse presents governments with numerous future opportunities. These particularly include prospects in addressing pressing urban challenges such as the delivery of healthcare (e.g., Telehealth), planning (e.g., development proposal modelling) and utilization of available urban spaces (e.g., joining social and music events), creation of new employment opportunities, education, etc., in diverse sectors. It is projected that in the future, urban governments will be able to manage activities, such as registration of persons and identity verification on virtual platforms, without the need for a physical presence, and the Metaverse will make the entire process feel real and authentic [9]. However, while the potential for urban governance in the Metaverse will be wide, it will require substantial investment and patience as the concept continues to evolve. This reminiscent of Hanna-Barbera's *The Jetsons* world. However, it will be a worthy cause for local governments to support the concept in their attempt to reap its diverse benefits. In particular, even before the materialization of the Metaverse, local governments could adopt some of the technologies such as AR, Blockchain and others to bridge the inequality gaps in cites.

For local governments, the Metaverse will provide opportunities to improve interactions with residents, offer fast, efficient, and real-time services, and better manage assets such as urban spaces. It will also open opportunities for new income streams, thereby allowing local governments to undertake complex and capital-intensive projects. In addition, the Metaverse will open opportunities for local governments to restructure existing urban planning models to embrace those that support human and social dimensions. Aside from governance entities, different institutions, including businesses, education entities, large corporations, etc., will offer opportunities to conduct their activities in the virtual world, enabling better interactions with existing and new clients, as well as improving the quality of their products by capitalizing on technologies such as DT that will be

enhanced in the Metaverse. They will further have opportunities to explore other frontiers such as creating virtual products that will be on-demand, as people seek to enhance their avatars, being future commodities, as the Metaverse becomes more apparent.

However, it is doubtful that the Metaverse will be able to address and overcome the common challenges of urban governance, including continuous negotiation and contestation, varied interests and incentives, disagreements and struggles, unpredictable decisions, inefficient collaboration, ineffective networks, and so on. Crafting the use of new forms of human collaboration through the use of advanced technologies will be directed towards other politico-economic ends rather than more open governance processes. Indeed, smart city governance has generally been criticized because it is strongly driven by government policies and the interests and agenda of high-tech companies and corporations. Consequently, many studies have focused on the potential risks and negative implications of the technocratic, corporate-led approach to smart city governance [93].

It will, therefore, be important to engage governance structures in cities, and at national levels, to ensure that the Metaverse is not geared for purposes that would negate the very purpose it is being adopted for [4]. As with smart cities, improving governance will require the participation of all stakeholders (public participation), with a decision-making structure based, not on trickle-down approaches, but, if and where possible, bottom-up approaches to render more comprehensive and inclusive solutions.

4.4. The Metaverse and the Quality of Life

The quality of life in urban areas is influenced by a myriad of factors that include transport and mobility, housing, health and sanitation, entertainment and recreation, physical infrastructure provision, economic and employment opportunities, education, and many others. According to [94], the difference in amount and mix of these assorted factors influences individuals' perception and satisfaction levels in relation to what they value as their quality of life. However, beyond individual perception, it is argued that at the minimum, factors such as socio-economic conditions, environmental sustainability, improved governance, and cultural diversity need to be in place to ensure the urban quality of life continues to increase [95].

It is evident that cities across the globe have diverse levels of those factors; hence, residents of these different urban areas have experienced different levels of quality of life. Further, with increasing modern challenges such as ecological degradation, climate change, pandemics, economic challenges, insecurity, and others, quality of life (including 'livability') in urban areas cannot be argued to have been static (improving or worsening). In most cities, the cited challenges have prompted a deterioration of human quality of life, with substantial resources being used to address and mitigate the situations [72,73]. This explains why the global community unanimously agreed through SDG 11 to address different urban challenges, including inclusivity and livability.

The use of technology to influence quality-of-life dimensions (including urban planning, transport, energy production, health, education, entertainment, and others) has been seen to help in addressing some of the aforementioned urban challenges. However, technology alone will not suffice as other factors such as financing continue to abound. However, with the prospect of the Metaverse, some of the challenges could be greatly mitigated. This may help urban residents experience some improvements in their quality of life. For instance, the prospect of offering some services, such as entertainment, education, civil services, virtual work environment, and many others in the virtual environment, is expected to help increase accessibility and equity. Such could also help reduce the time and resources spent by people commuting, renting, and paying for the services. As a result, with the ubiquity of service provisions, increased social interactions, increased information and unlimited opportunities, people will spend their resources in areas that create opportunities for personal growth, good health, social growth, etc. and hence improve their livability. However, it should be appreciated that, as of now, the Metaverse as

proposed does not offer solutions in reducing economic gaps; hence, warranting the local governments to explore alternative avenues to ensure that such gaps are reduced.

However, a little commented upon caveat is the capacity of technological accessibility stratification and discriminations that are presently occurring, whereby it is tech-savvy people who are driving technology adoption. This does not allow for 100% access for all citizens, especially the non-tech-savvy, the pre-laptop generations, and disabled persons. This then implies that there will be a need for inclusivity to be escalated even at individual levels to ensure that a majority of urban residents and dwellers, if not all, have the capacity to benefit from services that will shift to the virtual realm. Otherwise, the Metaverse might become another tool to widen the urban inequality gap that is already deep rooted in most cities.

4.5. The Metaverse and Social Interactions in Urban Settings

Cities have the unique characteristics of bringing diverse cultural strands together, highlighting the importance of our human social dimension. However, it has also been documented that due to factors such as the economy, politics, socio-economic inequalities, and capitalism, amongst others, the aspect of social interaction is very elusive [96]. This is further complicated by conventional urban planning models that promote elements like individualism affirmed by our emphasis on private car ownership, car type choice, the construction of high-rise buildings that do not promote mixed use, reduced number of recreation public spaces, and others [97]. Automation of different urban components also reduces urban social interactions, with most benefits skewed toward those with economic means and the educated. While urban areas are melting pots for cultural diversity, people barely have time to interact and reflect. This is the context in which new urban planning models such as the '15-Minute City' [13,76] and the 'Data-Driven Smart Sustainable City' [98] are gaining acceptance, as they not only emphasize the need to reduce reliance on automobiles but also the need for people to interact within their neighborhoods as they walk, ride bicycles or take time in recreation centers [99].

The ancient Greek philosopher Aristotle described human beings as 'social animals' [100], and as a result, despite the numerous urban hurdles and challenges that hinder them from having ample time to interact and socialize, they have found ways to fill the gap. This includes the use of social media and social platforms. But these too, have not been sufficient as they do not help fill the void of being 'close'. However, the prospect of a Metaverse that will offer opportunities to link the physical and virtual world seamlessly is already touted to be a solution for the social and interaction hurdles those urban residents experience. On this, many advocates argue that individuals will experience unprecedented virtual social experience via extended reality technologies. Thus, as Zuckerberg [8] explained, individuals will have opportunities to interact, play, host social events, explore new dimensions and do almost everything together in the virtual environment, just as in the physical world. More importantly, social barriers such as distance, racial segregation, and others that hinder physical social interactions will be overcome as people will have the ability to represent themselves in the form of avatars in the virtual environment [101].

However, as people increasingly pursue social interactions in the virtual world, questions on ethics, sexual predators, terrorism entrapment and indoctrination, privacy, and security concerns have been raised [102]. While these issues are reputedly recognized by big tech companies pursuing the Metaverse concept, they could deter people from enjoying and exploiting the total immersive experiences that the concept provides. The cost for hardware such as headsets and other products that will allow people to 'enter' the virtual world is also being seen as another challenge that may confront the Metaverse concept [19]. On this, there are possibilities that the poor and people of limited economic means may be 'locked out', continuing to perpetuate the social segregation that already exists in human society today. The Metaverse will also not suffice the interaction quest for people with different physical challenges, especially the blind and the deaf. Whereas the deaf may have some reprieve, the visually impaired will be greatly disadvantaged unless advanced technologies are available to address their plight.

Speaking of human society, the Metaverse may emerge to be a cyber-dystopia, causing major societal disruption. The idea of cyber-dystopia, as presented by [103] envisions a world which is made worse by technological advancements. One of its principles is losing control and becoming dependent. The digital experimentation of the Metaverse as a cyberspace will, if realized and widely deployed, become extremely invasive, recklessly encroaching upon the privacy of users, and take on the appearance of anarchy in the world due to the absence or non-recognition of the systems and regulations protecting the dignity or self-worth of users. The effect a cyber-dystopia in social interactions lies in the new media taking 'people away from their intimate relationships, as they *substitute* mediated relationships or even media use itself for face-to-face engagement' [104].

All in all, technological dystopia concerns itself with the (unforeseen) negative effects caused by new technologies which reflect and encourage the worst aspects of human nature [105]. However, this could not be worse than the situation that was created by the outbreak of COVID-19 that prompted global lockdowns, and were it not for technology, most activities in different parts of the world, especially in urban areas would have experienced untimely halting [85].

4.6. The Metaverse and Urban Tourism

Urban areas across the globe are defined by distinct characteristics that make them part of global tourism attraction centers. It is evident that a majority of tourism sites across the globe are driven by cultural values, as showcased by the UNESCO's World Heritage Lists [106]. In other cases, some cities such as Jerusalem, Hội An (Vietnam), Bruges (Belgium), Fez (Morocco), Bath (UK), and others are listed as World Heritage sites themselves [107]. In addition to the cultural heritage values in/of cities, there are numerous other aesthetic features, including unique buildings or structures such as museums, monuments, amusement parks, and others that are randomly distributed across the world. These tangible urban fabrics and monuments are complemented by a wide range of intangible heritages that cumulatively contribute to making cities culturally vibrant and thereby attractive as unique destinations for visitors [108,109]. However, urban tourism is prone to internal and external challenges like pollution, congestion, insecurity, seasonality, competition from emerging new trends, and many others [90–92]. It is also noted that urban tourism experiences financial challenges that complicate efforts for branding, conservation, and creation of new products [110,111].

The prospect of the Metaverse is expected to help address some, if not all, of these challenges that urban tourism faces. These include the ability to fuse the physical world with digital world (phygital), such that diverse tourist attraction sites could be accessed and experienced both physically and/or in digital forms [112]. The Lume in Melbourne, Australia, for example, has successfully achieved this outcome already in terms of art/place engagement [113]. This will be beneficial as people will have opportunities to virtually visit different attraction locations and interact with different DTs of varied physical locations, just as in the real world, providing opportunities for people who cannot travel to the actual locations to experience, explore, and tour diverse landscapes and products. While the emergence of the Metaverse may be deemed, at face value, an obstacle to the physical travel industry and its complementary businesses, it would not bring about the demise of the industry. For instance, it is not possible to replicate every aspect of the physical world in the virtual realm (e.g., smell and emotional and psychological attachment, especially regarding activities like mountain climbing or visiting the beach).

On the contrary, it is anticipated that the Metaverse will entice people to experientially visit such places in real time, and thus travelers will still find it worth traveling to experience these venues. Further, virtual reality will allow those businesses to showcase their products via virtual advertisements, so those willing to spend will already be familiar with what to expect [114]. More importantly, the Metaverse will help preserve and conserve fast-disappearing heritage and cultural attraction sites facing immense danger from urbanization, terrorism, increased climate change events, natural calamities, etc.

For physical attraction sites, especially urban heritage sites, the emergence and success of the Metaverse will have significant impacts, especially in relation to conservation efforts as it will be difficult to manipulate or destroy digital assets, unlike the case in the physical world, where numerous sites have been tampered with or destroyed altogether. The Metaverse will further influence attraction to the physical sites, increasing financial resources that could be used to support attraction sites, increasing the labor force and prompting the creation of new tourist products and services, thereby promoting employment opportunities for those working on the physical sites or those in complementary businesses like the hospitality industry. A case in point on this is the city of Santa Monica in California that is using a metaverse social app to improve the experience of the apps users as they explore the city. In return, the city benefits by promoting local businesses, which are important cogs in the city's revenue collection. In addition to such tools, it is now possible to adopt blockchain technology and non-fungible tokens (NFTs) to help preserve historical sites, especially by ensuring transactions involving these sites are based on digital currency. This will not only make such sites attractive amongst digital enthusiasts but will ensure that they are not devalued.

4.7. The Metaverse and Urban Climate Change Mitigation and Adaptation

In the last few decades, urban areas have endured unprecedented challenges from the impacts of climate change, with events and scenarios such as heatwaves, flooding, erratic weather conditions, and so on, and now major sociological and workplace changes prompted by the pandemic [115,116]. Unsurprisingly, the challenge of climate change is felt across the globe, with all urban areas at risk from a mixture of variables. At the same time, it is evident that urban areas have been at the forefront of resilience and adaptation measures aimed at addressing climate change whilst recognizing that such challenges are compounded when linked to increasing population, and increased consumption of resources (especially energy which in most cases is produced from non-renewable sources). Further, urban areas are home to almost two thirds of our global automobiles, and this movement system has been reported as contributing approximately 20% of the global emissions [117]. Overall, urban areas are reported as a major contributor of approximately 75% of global greenhouse gases, as most economic activities are domiciled in cities [118].

On the above, while significant efforts have been made to address the challenges, as captured in global accords such as the Paris Agreement in 2015, the United Nations General Assembly's Sustainable Development Goals (SDGs) of 2015, and the New Urban Agenda (NUA)–Habitat III of 2017, amongst others, it is evident that there is much that needs to be done. This was affirmed in a recent report by the Intergovernmental Panel on Climate Change (IPCC) that warned that the global temperatures were expected to rise 2 °C above pre-industrial levels. The global temperature targets as captured in the Paris Agreement are below 2 °C and preferably 1.5 °C pre-industrial levels [119].

While global policy emphasis on decarbonization is the new aspiration, as highlighted in the 2021 United Nations Climate Change Conference (COP26), the emergence of the Metaverse could have significant impacts not only on decarbonization but also in meeting other global climate targets. Core to Metaverse responsiveness to climate change is its capacity to reduce the need for human travel as people increasingly work virtually from home in an environment that mirrors their physical workplaces. Further, with increasing ability in hosting digital representations of physical objects, Metaverse will reduce resource consumption for products such as toys, games, festivity products, some recreation and entertainment products, and many others that often end up in landfills or are seldom used. This reduction will prompt a decline in energy use and, as a result, a reduction in the overall global emissions that are significantly influenced by energy production and consumption.

Regarding urban adaptation, as the impacts of climate change continue to be felt, most economic activities, including tourism in diverse cities, have been compromised, as attraction sites are being impacted by floods (e.g., Germany), rising sea waters (e.g.,

Venice), tsunami impacts (e.g., Tonga and Japan), siltation and other factors [120]. This, in turn, is impacting the livelihoods of many urban residents who are forced to seek alternative options, including migration and alternative employment opportunities after their livelihoods are destroyed [104,105]. However, with the Metaverse opening opportunities for new economic dimensions, urban residents working on already diminishing economic frontiers will have opportunities to take up the emerging alternatives for digital creators, performers, builders, gamers, and many others, as expressed by [121].

Additionally, the Metaverse can provide new opportunities by crafting better early warning systems for disaster responsiveness via digital platforms, hence leading to the protection of infrastructures and human lives. Even though the subject is still new, there could be arguments that the concept can also aid in the development of simulation and scenario mapping capacities to better understand the implication of plans and design of climate change mitigation tools. The application of digital simulations is becoming increasingly of value to existing eco-cities as one of the prevailing sustainable urban forms in regard to facing challenges to improve their resilience for mitigating the impacts of climate change in the face of urbanization [122]. Successful integration of nature-based solutions (NBS) into the urban fabric enables both the mitigation of climate hazards and the positive reaction of citizens. Examples of such NBSs include adopting vegetated walls and roofs in different infrastructures, increasing city trees, restoring wetlands, etc. These strategies help mitigate climate change by helping bring ecosystem services and benefits back into cities. The ecosystem services include air purification, micro-climate regulation, recreational opportunities, water regulation, and others which are all critical for urban resilience.

4.8. The Metaverse and the Urban Form

Technological advancement has changed the nature of the work environment, with most people seen to be favoring work-from-home models, as it has become increasingly possible to communicate, collaborate and fulfil different work-related tasks without visiting physical workplaces. This trend was amplified during the height of the COVID-19 pandemic, when a majority of the population was forced to work from home. This trend continues in the Omicron period (emerging in 2021), signaling how much technology has transformed the work environment by providing unlimited alternatives and conveniences [123]. The development of the Metaverse has, however, been argued to bring ultimate changes to the global workplaces, with diverse tools and different possibilities [124]. The fusion of the physical and virtual environment will mean that there will be very little difference between people working virtually and those working in a physical environment. The virtual world is even deemed to have more alternatives for the workers.

What will be more interesting to watch in the near future is how such transformations will impact urban forms as people will not need to be located in a particular place to access and perform their work. As a result, there are possibilities that people will opt to live outside urban areas, where challenges such as traffic, congestion, pollution, high cost of living, and others abound. With the ability of people to interact, socialize, play, and do practically everything in the virtual environment, the urge for people to migrate outside cities may become the future trend. After all, the Metaverse is expected to provide a wide range of alternatives such as Meta's Horizon Home platform, where people will have the ability to customize their virtual home and locate them anywhere in the virtual world [9]. In those homes, users will have opportunities to host and entertain friends as they interact in different activities; hence, the need to be physically near friends or families will be subdued. Such decisions will be further influenced by increasing online shopping trends, which proponents of the Metaverse promise will be made even better with the possibilities of presenting different products in 3D format, allowing people to interact with them before ordering.

As options for urban residents increase, it will mean that in the near future urban areas might not become as populated as has already been predicted, and the concentrations of dense multi-story office complexes will become redundant. If the urban population were to reduce, it will then prompt a change in urban infrastructure and form, as

urban planning will no longer be influenced by factors such as the need for travel and population density, but new parameters will emerge. However, noting that the Metaverse is still in its infancy [110], cities will remain the centers of attraction for many people pursuing different objectives. Even when the Metaverse finally materializes, urban areas, with substantial infrastructure already in place will still attract substantial populations. Still, the relationships between work and urban residential areas may have been pivoted and reconfigured, giving room to the adoption of planning models such as the '15-min city' concept [49]. The hyper-connectivity made possible by the Metaverse will play a further significant role in holding the appeal of cities, especially with increased revenue flows from increased digital transactions.

With reference to 'the data-driven smart eco-city' concept as a smart sustainable urban form [122], there are many natural components that are strongly associated with positive effects [111] and positive psychological states that occur in the direct presence of natural environments. Such effects and states include stress reduction [125], peak experiences [126], optimal attention span restoration [127], and positive emotions [128]. These benefits also occur when natural environments are presented through VR [116–119]. The natural scenarios in VR allow designers to simulate the influence of some natural conditions on emotional states [129]. Immersive simulations will likely increase the restorative effects of projected natural environments as part of the Metaverse. However, it is important to acknowledge the effectiveness of transformative simulations as tools for engaging citizens and investigating their future interaction with the environment through VR by means of e-participation. This solution can be exploited to visualize the design projects or their alternatives or even allow the direct modification by the user of the 3D model components [130].

5. Discussion and Conclusions

The prospect and increased attention on the Metaverse, especially after the unprecedented rebranding of Facebook to Meta, came at a time that the world has been grappling with numerous challenges requiring urgent solutions. One of these is the challenge of climate change that has continued to impact different aspects of the global environment, and as was acknowledged during the COP26 meeting, the challenge may worsen even before the end of this century [131]. The other major issue that has engulfed the world in the last few decades is the twin challenge of rapid population growth and unfettered urbanization. These two have been credited for triggering and exacerbating other issues such as climate change, resource depletion, socio-economic inequalities, and others that are mainly experienced in urban areas [132].

The third challenge that the world has been confronting is the COVID-19 pandemic that wrecked every facet of the global sphere [133], notwithstanding the numerous strides made in economic growth and social development in particular [16,125]. Surprisingly, these challenges have been increasing as the world has experienced the unprecedented emergence of novel and cutting-edge technologies that, in essence, would have helped overcome or mitigate the widespread consequences of climate change being witnessed today.

A summary of contributions and potential challenges of the integration of the concept of the Metaverse in urban settings is listed in Table 1 below.

Table 1. Perceived contributions and challenges of the integration of the Metaverse in cities. Source: authors.

Urban Sectors/Technologies	Contributions	Challenges
Urban resource management	• Reduces the need for travel • Decreases demand for physical infrastructure • Minimizing waste	• Metaverse technologies could be energy-intensive

	• Encourages the creation of new sustainable resources • Minimizes of extraction of and consumption of resources in some industry, e.g., entertainment industry • Provides open spaces for more interaction; hence, promoting participation of a majority in decision making on how resources could be utilized	• Might require substantial resources to produce enough physical products • Might encourage excessive resource consumption in the process of setting up infrastructures to support the concept • Will require a change in policies that might take time
Urban governance	• Enhances efficiency of service provision • Enhances accountability and transparency • Encourage equity in resources allocation and monetization • Might open new ways of interaction between different urban stakeholders • Catalyzes democracy, cooperation, and equality	• Large scale implementation could take time and be costly • Potential risks related to privacy and social control • Potential risk of misuse of personal data for privacy intrusion • Potential challenges in formulation of laws on different aspects of Metaverse • Potential to interfere with democratic spaces
Quality of life	• More equitable access to services • Health benefits • Social benefits • New job opportunities leading to increased disposable income • Potential to enhance urban security through improved surveillance • Reduces waste from technologies like digital twins that allow for prediction; hence, allowing for optimal resource use	• Addiction to activities like gaming resulting to low productivity; hence, low income • Potential risk of increasing cost of living • In cases it may lead to an increase in energy demand, and might result in more climate change related issues that would compromise the quality of life • Potential risks of health-related issues that might compromise the quality of life
Urban Social Interactions	• Potential opportunities for improved social interactions • Overcoming social barriers to human interactions • Feeling of presence • Allows people to innovate and create social activities, events and activities • Reduces geographical barriers that inhibit physical social interactions	• Potential issues related to ethics, privacy, and security • Requires costly equipment • Potential solitary physical lifestyles • Might become a new form of addiction • Might lead to more cosmetic relationship than real ones
Urban tourism	• Better accessibility to touristic attractions for all	• Problems for small businesses due to competition from virtual products • Cost issues

	• Enhances the possibility of tourist attraction through better advertising • Enhances conservation of heritage sites • Enhances financial revenues • Emergence of new products only possible in Metaverse	• Discourages the experience of physical experiences and places (e.g., use of sense of smell) • Might lead to neglect of some heritage site as their digital form will be present • Might lead to discrimination against the poor and people with disabilities (especially the blind) as they might not have the tools for them in the virtual reality environment
Climate Change Mitigation and Adaptation	• Reduces the need for energy-intensive activities • Better adaptation strategies • Reduces emissions from the transport sector • Reduces demand for some manufactured products like electronics • Promotes conservation programs of heritage sites in the process of promoting virtual tourism	• Potential risk of increase in unsustainable practices such as high energy consumption • Since it is in the infancy stage, cannot be relied on for climate solutions
Urban Form	• Encourages the building of human-centric urban areas • Allows adoption of models like the 15-min city concept • Promotes mixed use and multi-use of different urban assets • Promotes the adoption of diverse green projects like the creation of green spaces • Promotes the creation of compact urban areas	• Might promote gentrification • Potential risk of urban sprawl • Could promote the adoption of new modernist planning models that have no capacities to promote human dimensions

At different scales, the aforementioned challenges have impacted people in such a way that a majority, especially in urban areas have no time or opportunities to pursue basic human needs (such as socialization, self-actualization), access health and education services, or even have time for play, entertainment or innovation [134]. These challenges have further prompted an increase in such issues as unemployment, compromise of culture and cultural heritage, and many other issues that directly impact human life. The envisioned Metaverse is, however, expected to help people solve some of these challenges by providing unparalleled opportunities for social interaction with friends and family despite the physical geographical distances [46]. It will also allow people to work, innovate and collaborate with colleagues and peers while not having to travel to physical workplaces [9]. In the meantime, it will help address the challenges of cultural disintegration by providing numerous opportunities for people to preserve, conserve, showcase and pursue their tangible and or intangible cultural heritage in ways that are not possible in the physical realm.

As highlighted above, the prospect of fusing physical and virtual realities will further play significant roles in addressing challenges such as climate change, as the need for resource utilization to produce some goods and products will be solved. This can be explained by the fact that most of those goods and products could be stored as virtual products, such

that they would be shared by an unlimited number of people without compromising on their quality or quantity. The Metaverse will further prompt a change in urban morphology, as factors like vehicular flow will not influence planning models. Instead, the success of this concept might accelerate the actualization of planning models such as the 15-min city concept that is more inclined to support human and social dimensions [13,78].

All the prospects that the virtual environment is projected to make possible, though only through technological advancements, may open opportunities for the world to continue supporting the increasing population. After all, even the proponent of this new technological marvel is advising for patience, as they concede that a lot of resources, time, expertise, collaboration, and innovation will be required to knit the different pieces and ideas together [46]. The development and actualization of this concept are also expected to be hinged on advanced technologies, software, and hardware that are not presently sufficient to allow for the anticipated immersive experience. The aspect of financing will also be very critical as most of the prerequisite hardware and software require massive resource mobilization [44]. This is particularly important, especially if the pursuit of this concept was to be paralleled with other technological concepts such as the smart cities planning model that is championed for its promise to transform urban areas [132,135]. Though, despite the potential that the planning concept holds, it has not fully materialized in many economies, notably and partly because of financing challenges [135,136]. Therefore, even as corporations, big tech companies, governments, and other players substantially invest in actualizing the concept of Metaverse, they should also factor in the plight of economies and individuals at the middle and bottom of the economic pyramid to ensure that they are not left behind. At the bare minimum, it will be important to ensure that the required infrastructure, hardware, and software are sufficiently provided to facilitate accessibility and affordability.

Though the Metaverse concept might eventually become a reality in the foreseeable future, it will be critical for the global community not to relent in pursuing frontiers such as climate change mitigation, cultural heritage conservation and preservation, and exploring alternative planning models that have equal capacities to address the existing common challenges. This is important because some challenges, such as climate change, are exerting unprecedented pressures on the global fabric, especially in urban areas and in economies such as Small Island Developing States (SIDS), and because, by the time the Metaverse concept become a reality, some of the most vulnerable economies might have been severely affected.

Regarding the challenges related to users, one of the key ethical issues posed by the Metaverse, which Facebook has proven to fail in addressing and overcoming, is privacy. This is a real concern because Facebook and other big tech companies are determined or will certainly collect users' personal information, share it, trade it, and abuse it. This occurs through online interactions and biometric data from wearable virtual and augmented reality devices [19], adding to dataveillence and surveillance. The era of big data marks the end of privacy, especially since the amount of data collection in the Metaverse will be far greater than that on the internet today. Moreover, user addiction, coupled with the problematic use of virtual social media platforms, constitutes another concern that is difficult to address and overcome by the Metaverse. Complete dependence on the Metaverse due to its immersive and 3D platform will result in impairment and inaction in users' functions and activities in their life over a prolonged period, adding to other mental and physical disorders with severe repercussions in terms of harm. Given the complexity and controversy surrounding the research and debate in this area, evidence-based recommendations for policymakers will be difficult to develop and implement.

All things considered, the Metaverse is, just like all techno-visions, affected by political practice in relation to climate change, shifts to new modes of the economy (low-carbon and digital), ecological modernization, technological and scientific advances, and governance shifts, as well as by the knowledge/power relationship established in Western society [137]. These will determine, expand, and probably maintain its expansion and success, at least for a certain period of time. From a philosophical perspective, the Metaverse can be seen as a discourse of using computational and scientific approaches and inquiries in

social connection, inspired by recent technological advancements that historically become fashionable before quickly disappearing as they become situated in experiences. 'All knowledge about reality begins with experience and terminates in it', as stated by [138].

The development of the Metaverse is still in its early stages, and research in this area is in its infancy and fragmented along disciplinary lines, so there is little understanding of the actual opportunities and implications of this global platform. But what is certain is that the idea of the Metaverse has already raised serious concerns over the risks and impacts of its underlying core enabling technologies with respect to human, ethical, and social values. Konkova and Gurov [139] explore the grounds on which big tech companies seek to transform mankind's way of life and the nature of the "human", based on the idea of the Metaverse. Using a comparative analysis, the authors highlight the opportunities and threats that the Metaverse pose for humanity in the conditions of uncontrolled technological development, calling for the formation and dissemination of a new socio-humanitarian rationality as a necessary condition for the successful development of the Metaverse, or rather, the concept of the Metaverse should it be envisioned to play a pivotal role in future digital societies. It needs to be nurtured, not only by those in the tech world, but by different players to ensure that, as it comes into fruition, all the possible pathways that would lead to unparalleled benefits are explored. This approach will ensure that equitable and inclusive pathways are identified and developed. However, in doing so, there are many risks and, in this regard, hurdles that might arise also need to be identified and possible solutions proposed. For example, Bibri and Allam [140] address the question: What ethical implications will the Metaverse have on the experience of everyday life in urban society? To answer this question, they examine the forms, practices, and ethics of the Metaverse as a virtual form of data-driven smart cities, paying particular attention to privacy, surveillance capitalism, dataveillance, geoveillance, human health, and collective and cognitive echo-chambers. The authors argue that the Metaverse will do more harm to human users than good due to the massive misuse of the hyper-connectivity, datafication, algorithmization, and platformization underlying the global architecture of the computer mediation pertaining to the Metaverse. It follows that the Metaverse needs to be re-cast in ways that re-orientates how users are conceived, recognizes their human characteristics, and takes into account the moral values and principles designed to realize the benefits of socially disruptive technologies while mitigating their pernicious effects.

Furthermore, it will be important to raise and address other provocative questions before the world is 'immersed' in this new 'universe'. Regarding this, it is topical to seek answers to questions such as what will be the governance structures of the Metaverse, and what will be their limits? Will it be possible to synchronize activities in both realms (physical and virtual) in such as a way that activities in the Metaverse will be legally acknowledged in the physical world, such as trading of virtual land and other assets? Among other things, would the Metaverse, being a digital replica of our physical world, replicate the prejudices and social wrongs? Answers to these questions will be key in shaping future digital societies and lead to more accessible and inclusive frameworks, responsive to social needs and to the SDG 11.

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