

# Metaverse for Public Welfare and the United Nations Sustainable Development Goals

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**Abstract.** Metaverse is extremely popular at present in the gaming industry but can it accelerate the advancement of public services as defined by the United Nations Sustainable Development Goals (UN SDGs)? In particular, can metaverse provide any value to developing nations and how can the challenges and risks introduced by the metaverse be addressed through government regulations and policies? This paper presents a systematic analysis of metaverse and utilizes the United Nations SDGs as a metric to explore public welfare aspects of metaverse. A digital transformation Lab is presented for rapid deployment and experimentation with metaverse.

**Keywords:** Digital Transformations, Metaverse Cities, Smart Global Village, UN SDGs, SPACE Toolset

## I. INTRODUCTION

The British science fiction novelist Neal Stephenson introduced the term metaverse in 1992 to describe a virtual world that only existed on the internet [1]. Over the years, this concept has morphed into a large-scale network of popular computer-generated worlds -- a Google query yields more than 200 million results at the time of this writing and Goldman Sachs has estimated that the metaverse could ultimately be an \$8 trillion opportunity. Metaverse resides on the Internet with virtual users (avatars), houses, streets and properties [2]. Gamers around the globe and many large organizations such as Facebook (now known as “Meta”) have jumped on the metaverse bandwagon. The idea is now being explored for numerous public welfare applications and several “Metaverse Cities” such as Seoul [3] have been announced.

Simply stated, metaverse is a convergence of several digital technologies (let us call them “*Meta Technologies*”) to create a persistent virtual world. Examples of these technologies are:

- Virtual Reality (VR) that completely excludes the real world and Augmented Reality (AR) that is a combination of real-world artifacts and VR. AR/VR presentations are typically viewed through specialized lenses.
- Blockchain (basically a digital ledger that is stored in such a manner that it cannot be modified) and Non-Fungible Tokens (NFTs) -- a unique digital identifier that is stored on a blockchain and can be sold and traded. Blockchains also enable crypto currencies that can be used in the Metaverse to buy and sell virtual property and goods such as paintings and music.
- Web 3.0 (third generation semantically rich web content that can be understood by other machines and can be stored on a blockchain) – any web page could be a block on the blockchain. Thus, a web page could be owned and traded in an NFT marketplace.
- Artificial Intelligence (AI) when machines emulate intelligent human behavior and Machine Learning (ML) where machines learn directly from available data *without* human intervention.

Metaverse is basically a convergence and integration of these, and some other, technologies to develop extremely powerful virtual worlds that reside on the internet with almost unthinkable overtones [2, 3, 19-25, 41, 42]. Our objective is to answer the following key research questions:

1. What exactly is metaverse and how can it be used to improve the lives of underserved populations around the globe? See Section II for answers.
2. Can metaverse be used to address the human needs as indicated by the UN SDGs (i.e., health, education, public safety, public welfare, food, shelter and others)? Specifically, can the current organizations and their services be transformed rapidly to metaverse so that they can be of value to the developing nations quickly? See Section III for some ideas. The UN SDGs are defined in [7].
3. What are the new issues that metaverse raises, what type of regulations will be needed to address these issues, and what approaches could be of value? See Section IV for details.

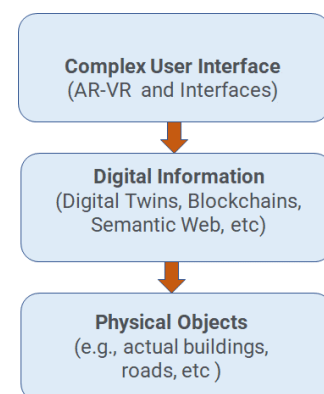
## II. A CLOSER LOOK AT METAVERSE WITH EXAMPLES

Many examples of metaverse are in the gaming sector. The following short examples highlight metaverse for possible public welfare, more examples will be provided in Section IV.

- *Avatar as a Robot*: An avatar in metaverse is usually a digital twin of a physical robot. Thus, robotics can be studied by using metaverse digital twins. An interesting humanoid robot, called ICub3, is being developed in Italy than can be sent in place of humans to dangerous areas and a human connected remotely to the robot can see and feel *everything* the robot can (e.g., the heat in the building). The researchers are attempting to apply this technology to avatars in the metaverse for scenarios such as a disaster response (i.e., sending in a robot to an unstable building to rescue someone) or to healthcare, where a surgeon could remotely operate on a patient [13].
- *A Metaverse eCommerce Community*. Metamerce is an integrated community of amusement offering buying and selling, content creation or music composition, social or professional networking, chatting domains and 3D gaming. It uses a centralized blockchain to allow merchants to add their stores and enables crypto holders to pay with crypto currency. Metamerce assumes that all digital and tangible assets in the future will be stored, traded, or transacted primarily through the blockchain [14].
- *A Metaverse City*. Seoul as the First Metaverse City was announced in November 2021. It will allow citizens to request and receive almost all government services through avatars without leaving their homes [3]. This US\$287 million initiative consists of over 1,000 projects that include establishing its own metaverse platform, developing blockchain-based services, expanding AI-powered Closed-Circuit TV, and investments in AI, IoTs, big data and a blockchain-based wallet application for managing government-issued certificates [26].

The main idea of metaverse is that it converges the Meta Technologies to create the aforementioned powerful virtual worlds and many more in marketing, tourism, healthcare, and agriculture. We will discuss these briefly in the next section. However, all metaverse examples can be conceptually represented in terms of the following 3 layers displayed in Figure 1:

- Advanced user interface with AR-VR capabilities instead of current flat screens that will interact with the digital twins (it will help build, detect and work with digital twins).
- Digital Information layer that will house and process the digital twins of the real-world objects such as buildings, roads and furniture. It is a mixture of semantic web content, blockchains, and AR-VR content in different formats.
- Physical layer that maybe the actual physical objects such as houses, people, cars, trees and roads. This is the world that we view through our natural senses such as sight, touching and hearing.



**Figure 1.** Metaverse Conceptual View

Development of a typical metaverse project starts with building the needed digital twins and then construction of the AR/VR user interfaces.

### III. METAVERSE FOR PUBLIC WELFARE – A QUICK ANALYSIS BASED ON UN SDGS

Table1 illustrates how metaverse can possibly support the 17 UN SDGs. The first column shows the comprehensive UN sustainable goals that span poverty reduction, food and agriculture, healthcare, education, gender equality, water and sanitation, energy, economic growth, industrialization and innovation, inequality, safe and smart cities, climate change, conservation of oceans, sustainable terrestrial ecosystems, peaceful societies and global partnerships to achieve all of the above. These goals, defined in [7], were announced in 2015 and have been a major mission of the UN to be satisfied by 2030. The second column of Table1 suggests how metaverse can specifically support these goals. The table illustrates that metaverse has a great deal of potential to accelerate the public and private sectors related to SDGs.

**Table 1.** The Possible Role of Metaverse in Supporting the UN SDG AGENDA

(Note: This table is a major extension of Umar [16])

UN SDG Goals	The Possible Role of Metaverse to Support SDGs
Goal1. <i>End poverty in all its forms everywhere.</i>	Metaverse can encourage young entrepreneurs and promote new and imaginative cottage industries. This is a significant improvement of current eCommerce hubs that support cottage industries for economic development [8, 18]
Goal2. <i>End hunger, achieve food security and promote sustainable agriculture.</i>	A huge impact of Metaverse could be on indoor farming because the indoor farmers are investing in the latest technologies for sustainable and hassle-free agriculture [19]. In addition, immersive tutorials for operating complicated agriculture machinery are of immense value and blockchains can be used for secure distribution and storage of food. The use of IoTs to increase, protect, and optimize crop production is also a very promising area of work. These developments could collectively strengthen the agricultural hubs in multiple locations with precision agriculture and food safety capabilities [8, 9, 10, 11].
Goal3. <i>Ensure healthy lives and promote well-being for all at all ages.</i>	The “Meta Health” is rapidly gaining traction with convergence of AI, AR/VR, IoTs, quantum computing, and robotics. These are expected to change the healthcare delivery and improve patient outcomes. In addition, digital robots (avatars) can be used for aging and disabled populations for routine household tasks. Meta (formerly Facebook) has published guidelines for developers to keep disabilities and accessibility in mind for metaverse applications. Meta Health services can also integrate e-health, e-learning, and e-administration capabilities for delivery to multiple locations. [9, 17, 20].
Goal4. <i>Ensure quality education and promote lifelong learning for all.</i>	Metaverse capabilities can nourish, enrich and transform traditional online learning environments to higher levels. The tutorials for adult education could be provided through capacity building centres that offer immersive tutorials and gamifications. These centres could also help students with disabilities. [8, 9, 21]
Goal5. <i>Achieve gender equality and empower all women and girls.</i>	Metaverse hubs are gender neutral and should be strategically located at sites that are suitable to everyone regardless of age and gender (e.g., not internet cafés in bars) [8, 9, 10, 11].
Goal6. <i>Ensure availability and management of water and sanitation for all.</i>	Metaverse can support “Digital Water” initiatives at global levels (see the International Water Association (IWA) Digital Water Summit [15]). These initiatives also enable sensor-based smart water pumps and sanitation outlets for rural populations and educational institutions.
Goal7. <i>Ensure access to affordable, reliable, sustainable and modern energy for all.</i>	Metaverse will definitely consume more energy. However, extensive use of Meta Technologies (AI, ML, IoTs, and Blockchains) is necessary for management and control of energy consumption. Another consideration is that a successful Metaverse could greatly limit travel emissions on both local and global levels because white-collar workers would not need to commute to work every day. [22]
Goal8. <i>Promote sustained, inclusive and</i>	AR/VR could produce very attractive virtual tours that are of great economic value to developing countries. Also, metaverse can be used to support entrepreneurship,

sustainable economic growth.	cottage industries, tourism, fisheries, blue economies, industry4.0 and Manufacturing4.0 in different geographical areas. [8, 9, 23]
Goal9. <i>Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.</i>	There are numerous opportunities for innovative digital twins in industrial settings. Many entrepreneurs can support the planning engineering and management tasks of Metaverse. Metaverse usage will considerably accelerate the adoption of Industry4.0 and Manufacturing4.0 projects [8, 24, 41, 42]. This adoption will create a very well-trained workforce that will trigger highly innovative industry projects.
Goal10. <i>Reduce inequality within and among countries.</i>	Meta hubs devoted to different topics of common interest and located in different parts of the world could help reduce inequalities. These hubs could collaborate with other hubs on different topics and engage multiple populations around the globe.
Goal11. <i>Make cities and human settlements inclusive, safe, resilient and sustainable.</i>	Use of metaverse extensively in smart communities and cities can trigger many innovative public service applications. For example, the Seoul Metaverse City initiative will allow citizens to request and receive almost all government services through avatars without leaving their homes [3]. This topic needs more research.
Goal12. <i>Ensure sustainable consumption and production patterns.</i>	Many complex consumption and production scenarios can be simulated by using metaverse technologies. Metaverse capabilities need to be investigated seriously for inventory management, warehousing, production, and supply chain improvements. [9, 11, 12].
Goal13. <i>Take urgent action to combat climate change and its impacts.</i>	Metaverse could reduce the need for travel and be good for climate change due to less emissions. Sophisticated metaverse models for climate change could be used to create advanced visualizations of different scenarios. Metaverse models could help measure changes in ocean waves, predict weather conditions and detect earthquakes. These models could integrate sensors, BI and Big Data with Meta Technologies. [8, 10, 26]
Goal14. <i>Conserve and sustainably use the oceans, seas and marine resources.</i>	Blue Economy scenarios and undersea explorations can be based extensively on metaverse models. Examples could include inter-connected sensors in various locations that upload the information to satellites to help construction of sophisticated visualization and analytical models [9, 10, 11]
Goal15. <i>Protect, restore and promote sustainable use of terrestrial ecosystems.</i>	Use sophisticated metaverse models to predict and detect wildfires quickly. Also use AI/ML and connected alarm systems across urban areas to alert authorities and notify residents of potentially fast-moving fires. Similar techniques could be used in detecting and tracking heavy rain and wind storms.
Goal16. <i>Promote peaceful and inclusive societies.</i>	As reported in a World Economic Forum report, metaverse use can result in <i>peaceful and inclusive societies</i> . Also, IBM Smarter Planet model supports inter-agency interactions and improved governance [41, 9, 10].
Goal17. <i>Strengthen the global partnerships for development.</i>	Metaverse services, as noted in Harvard Business Review and the United Nations studies, can help establish global partnerships and G2G (Government to Government) communications [42, 16, 8].

#### IV. POLICY ISSUES AND RISKS AT A GLANCE

Metaverse technologies, as displayed in Table1, can possibly accelerate SDG progress significantly. However, they raise several legal and policy issues such as the following [26] – [31]:

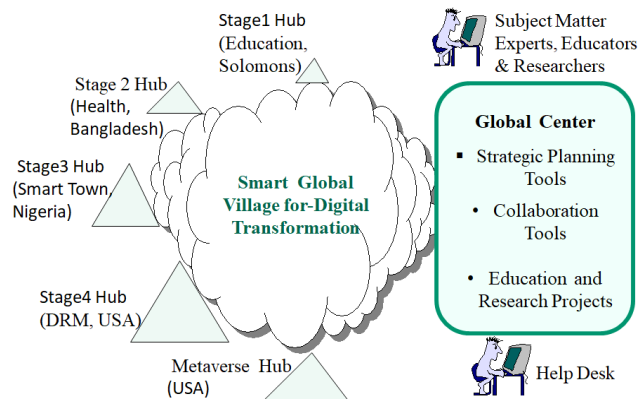
- Metaverse requires expensive lenses, CPUs and very fast networks. This may limit the potential users of metaverse to only well-to-do populations and countries.
- Major data privacy concerns have been raised in the proposed Metaverse cities such as Seoul. For example, closed circuit TV (CCTV) is expected to watch and record all movements of its citizens in Seoul. This has triggered serious criticism [26]. Data stewardship is also crucial because children growing up in an increased AR/VR world may not be able to distinguish real artifacts from virtual.
- Metaverse in the hands of bad actors is a major concern. For example, dangerous messages can be injected, and false alarms and disasters can be triggered because they could look very real. In addition, digital avatars of the future can be based on the expert systems of the past. These avatars may look like us but may use their knowledge (“expertise”) to perform malicious and dangerous acts. This introduces numerous legal and social issues that could create demand for future lawyers who specialize in “Meta-Crime” and “Meta-Forensics” [30].

- As mentioned previously, the metaverse requires expensive equipment and thus is of little value to developing nations. Approaches such as Smart Metaverse hubs may be needed (see section V for details). In addition, policy makers will need to make sure that inclusion, public safety and public welfare considerations drive the technology regulations so that no one is left behind.

Basically, a next iteration of the Internet is being created by the metaverse that is introducing new opportunities and challenges [41, 42]. Karen Baker, in a Harvard Business Review article, points out “... As we create the next iteration of the internet, the stakes are too high to exclude diversity, equity, and inclusion (DEI) from the conversation” [42]. Some progress in this regard is being made. For example, the World Economic Forum has partnered with Meta, Sony, Microsoft, and others, “to create an ethical and inclusive metaverse” [41, 42]. As a working example, an inclusive virtual marathon was held in April 2022 where a company partnered with disability experts to design participants’ avatars, which included wheelchairs, prostheses, and a variety of descriptive and audio aids for people with different impairments [42].

### V. A DIGITAL TRANSFORMATION LAB FOR METAVERSE AND SMART HUBS

We have developed a Digital Transformation Lab, displayed in Figure 2, that is based on our work with the United Nations and other non-profits around the globe [6, 16, 36-40]. The transformation is based on several approximate stages: Stage 1 represents Brick and Mortar Enterprises, Stage 2 and 3 are in the initial and middle stages of automation, Stage 4 enterprises are using Industry 4.0, and *Metaverse* hubs go beyond Stage4. The Lab tools help enterprises to gradually transition from lower stages to higher. The Smart Global Village, displayed in Figure 2, currently accommodates over 1400 smart hubs that represent over 140 countries and 12 industry sectors. This Village is an excellent sandbox for students, industries and government officials for a wide range of digital transformation investigations (see [5, 6, 32] for details).



**Figure 2.** A Use Case for the Smart Global Village that includes Developing as well as Developed Countries

This Smart Global Village could be used as an interesting *Metaverse Sandbox of high value to the developing as well as developed countries*. Please note that these hubs are in different stages of digital transformation, locations and provide services in different SDG topics. A Global Centre monitors the activities of the hubs. Table 2 provides a quick tour of the Lab with links to videoclips and key websites. We are currently preparing advanced experiments with the metaverse hub (Stage4+) to better understand immersive education, tourism and disaster resilience. The interactions between metaverse and lower stage hubs in developing countries are of particular interest to us.

**Table2:** Quick Tour of the Lab

<i>Short Videoclips (2 to 3 Minutes)</i>	<i>Websites - For experiments, please login as a guest</i>
<ul style="list-style-type: none"> <li>• Digital Transformation Advisor, Video Clip [37]</li> <li>• SPACE Factory: Video Clip [38]</li> <li>• Smart Collaborating Hub: Video Clip [39]</li> </ul>	<ul style="list-style-type: none"> <li>• The SPACE eFactory [35]</li> <li>• Smart Global Village Sandbox [40]</li> <li>• Digital Transformation Advisor &amp; Planner [33]</li> </ul>



## VI. CONCLUSIONS

This paper has shown that metaverse offers many capabilities that could be of tremendous value to public welfare as specified by the UN SDGs. But several social and policy level challenges must be addressed. To better understand the different aspects of metaverse, we have developed a systematic methodology and a Lab for experiments. Special attention is being paid to the use of metaverse in the large metropolitan areas of developing countries. We are currently using and extending this Lab heavily.

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