Assessing Virtual Reality Media Productions: Findings from a Qualitative Analysis of Immersive Experiences in Climate Change as Offered via Oculus TV

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ABSTRACT

This study explores virtual reality (VR) uses in climate change storytelling. The study uses a mixed approach, i.e., qualitative content analysis, experiential media (EM) theoretical model, and the United Nation's Intergovernmental Panel on Climate Change special report's framework on the climate crisis. This study looks at nine different VR media productions on climate change available on the Oculus TV, a VR application by *Meta Platforms Inc* (formerly *Facebook Inc*). The nine VR media productions observation and experience involved the use of Oculus Quest 2 Head-Mounted Display (HMD) to understand: 1) to what extent do the VR media productions utilize six qualities of EM; 2) what themes do such VR media productions highlight pertaining to climate change, and 3) to what extent do such themes capture key points highlighted by the landmark IPCC 2018 special report's framework. The findings revealed that all the nine VR media productions utilized limited qualities of EM, i.e., (1) interactivity, (2) immersion, (3) multisensory presentation, (4) algorithm and data, (5) first-person perspective, and (6) natural user interface. The findings also revealed five broad thematic categories, including global warming; biodiversity & endangered species; culture & traditions; conservation & disaster management; and agriculture, along with various sub-themes identified from all the nine VR media productions. The thematic analysis showed that the VR media productions utilized limited framing and contextualization of the issues pertaining to climate change — as opposed to the multidisciplinary approach that the IPCC report takes and offers as a framework to help people understand the gravity of the problem caused by climate change. The study extends the theoretical understanding of the role VR plays in highlighting the climate crisis and provides practical implications on the uses of VR for climate change storytelling and reporting.

Keywords

Virtual reality, climate change, experiential media, IPCC 2018, immersive environments

INTRODUCTION

The world is warming. It is 1.0°C higher than it was during the pre-industrial era, and currently heading towards 1.5°C between 2030 and 2052, and 3.2°C by the end of the century, according to the United Nation's Intergovernmental Panel on Climate Change report (IPCC, 2018) and UN Environment Programme's Emissions Gap Report (UNEP, 2019). This change in global temperature

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is flagged as dangerous to the natural world, considering the fact that in the last 10,000 years of the Holocene period, Earth has been largely stable where the average temperature has not wavered up or down by 1.0°C. Such a rise in the global temperature, unchecked human activities, and its influence on the natural world have put as many as one million species of plants and animals at risk of extinction in the near future, according to the UN's Report on Biodiversity and Ecosystem (IPBES, 2019).

These comprehensive assessment reports released in 2018 & 2019 have shown nature's dangerous decline at an unprecedented scale caused by human activities. As Sir Robert Watson, the chair of the IPCC report, puts it, "We are eroding the very foundations of our economies, livelihoods, food security, health and quality of life worldwide" (IPCC, 2018). The media has been quick to acknowledge these facts and bring them to the public's attention. In fact, the year 2019 witnessed a 'bigger and better' coverage/reporting on climate change issues compared to the past years. According to Yale Climate Connections, which has compiled three different reports from Media Matters (a media watchdog group); Media and Climate Change Observatory (MeCCO) at the University of Colorado, Boulder; and Pew Research Center, "Television coverage on Climate Change issues was up 138%; while print coverage, by the five national newspapers tracked by MeCCO, was up 46%," (Svoboda, 2020).

It can be noted that worldwide media organizations (including those specialized in news and documentaries) are increasingly taking a multidisciplinary approach/stand on local issues while highlighting natural disasters and erratic weather conditions. One such example is the frequent California wildfires. Media, with the help of scientists, are now able to pinpoint the cause of the increase in wildfires to the prolonged drought in the Western ecosystem since the 1990s due to the increase in average global temperature, which has resulted in a much more hospitable environment for the 'bark beetle' to thrive and invade the entire ecosystem. These tiny insects burrow through the bark to lay their eggs in the tree's living tissue, thereby killing the tree. California fire department estimates 129 million dead trees from drought and bark beetle infestation (Leefeldt, 2018). Another example is the frequency and intensity of hurricanes in the United States that are now seen as a consequence of global warming, according to multiple reports in the media and non-profit platforms recently.

With rapid advancements in media technologies, emerging and more experiential media such as VR can be seen utilized by media organizations to help in 3D visualization and present scientific data in immersive ways. The current VR technology offers media outlets to embedded content for users to navigate the many-layered elements of a story; incorporate haptics 'sense of touch' as part of the narrative; and present data-driven features where users can interact through eye-gaze-based interaction or gesture (including hand, arms, head, or movement of the body). Such VR media productions are now made available and accessible on immersive platforms such as Oculus TV, Netflix VR, and YouTube VR for users to make practical contact or experience with phenomena virtually. The user experience is not passive but can be interactive in such a virtual sphere due to VR's potential to offer multisensory engagement such as haptics, gestures, auditory interaction, and immersion, including 360 degrees of visual and auditory envelopment.

Considering such immersive nature of VR, a growing body of literature, as highlighted in the following review, shows that VR first-person experiences could increase pro-environmental behavior and climate action among people. However, limited scholarly work has explored from a qualitative standpoint how and to what extent VR media productions on popular VR platforms utilize experiential media (EM) qualities, particularly on global issues such as climate change.

The current study seeks to understand how VR media productions on popular immersive platforms such as Oculus TV, owned by *Meta Platforms Inc* (formerly known as *Facebook Inc*), are utilizing qualities of VR to tell the stories pertaining to climate change; what themes such VR media productions on Oculus TV highlight pertaining to climate change; and whether such themes offer a multidisciplinary point of view on climate change as offered by the landmark IPCC 2018 special report's framework that provides insights on the framing and contextualizing of climate change.

A growing body of research indicates that emerging media technologies, particularly VR, are diffusing widely worldwide, thereby transforming media practices, content and user experiences. The review of literature – to gain insights and to identify a gap in the literature – for the current

study can be broadly categorized into two areas: (1) the affordances of VR as an immersive tool and its uses and effects in climate change storytelling, and (2) framing of climate change messages and its effects on people.

The Affordances, Uses and Effects of VR in Climate Change Storytelling

Scholars such as Markowitz & Bailenson (2021) highlight the connection between VR climate change and contend that VR as technology has become a medium for education about climate issues and a way to indirectly expose users to novel stimuli and tell stories about anti-environmental activity. Markowitz & Bailenson identified three primary VR technological affordances (1) presence, (2) immersion, and (3) embodiment to help create a meaningful psychological experience. Speaking of psychological experiences, Petersen et al. (2020), in their study, implemented an immersive virtual field trip (VFT) within their investigation phase of an inquiry-based learning climate change intervention to identify whether VFTs increase important variables such as declarative knowledge, interest in science, and intentions to take climate actions. Petersen et al. involved randomly selected 102 seventh and eighth-grade students to travel virtually to Greenland and explore albedo and greenhouse effects firsthand. The researchers found that in both conditions (i.e., 1) narrated pretraining followed by immersive VR exploration, 2) and the same narrated training material integrated within the immersive VR exploration), participants showed a significant increase in declarative knowledge, self-efficacy, interest, STEM intentions, outcome expectations and intentions to change behavior from the pre-to post-assessment.

Petersen et al. (2020) contend that "From a climate change perspective, the fact that the students across conditions showed significant improvements in behavioral change intentions is highly promising and highlights the potential of immersive VR, in connection with relevant educational activities, to decrease psychological distance and thereby increase climate action," (p. 2110). Similarly, in another separate study, also exploring immersive VR field trips and learning about climate change, Markowitz et al. (2018) conducted four studies with two controlled lab experiments to test the efficacy of immersive VR as an educational medium for teaching the issues of climate change. Markowitz et al. conducted lab experiments involving 270 participants who experienced immersive underwater VR content highlighting the effects of rising seawater acidity. Markowitz et al. found that participants who experienced VR content demonstrated knowledge gains about climate change and also displayed more positive attitudes toward the environment after pre-and-posttest assessments. Markowitz et al. highlight that the more people explore the immersive/spatial learning environment, the more they demonstrate a change in knowledge about rising seawater acidification.

Meanwhile, in order to test the claims whether VR, particularly 360-degree envelopment, is capable of creating empathy (due to the medium being immersive) and whether wearing a head-mounted display (HMD) encourages a full immersive experience, Tse et al. (2017) conducted a study involving 40 participants in a lab setting and explored whether 360-degree viewing platform including magic window (Magic window involves the use of mobile phone, where the viewer moves smartphone or taps with finger to navigate) and google cardboard HMD use (where the viewer moves head and/or body to navigate) have an effect on film-immersion for the 360-degree video titled 'Fire Rescue'. Tse et al. found a significant interaction effect among participants where the HMD increased immersion for google cardboard but decreased immersion for the magic window. Tse et al.'s study also highlight that HMDs increase presence but do not necessarily lead to more empathy and greater interest in the 360 videos.

Overall, Tse et al.'s findings have implications for filmmakers and researchers of 360 videos. Similarly, in their study, Pimentel et al. (2021) explored the role of social presence and interactivity in building empathy in 360-degree video. Pimentel et al. mainly looked at how 360-degree videos about Alaskan climate change refuges can encourage empathic outcomes through factors such as social presence and interactivity. Pimentel et al. found that social presence contributes to prosocial behaviors, i.e., donations through empathic concern, an effect augmented by interactivity. While Pimentel et al. findings extend the existing literature exploring the relationship between spatial presence and empathy for mediated other, Pimentel et al. also contend that "creating a sense of "being there" is not 360 video's de facto route to empathy. With participants reporting similar levels of spatial presence during the 360 videos, the results demonstrate that cultivating a sense of

"being with" story characters effectively increase empathic concern for them, which in turn contributes toward prosocial behaviors and intentions," (Pimentel et al., 2021, p. 2245).

Furthermore, studies have also explored the importance of visual imagery in public engagement with climate change-related content. Exploring the importance of visual imagery in public engagement with climate change-related content, O'Neill & Smith (2013) conducted a critical review of literature pertaining to visual representation (2D, 3D, and VR visualization) of climate change and public engagement with visual imagery. O'Neill & Smith (2013) identify three important themes common throughout the review, which is time, truth, and power – where visuals are utilized as a key communicative tool for visualizing climate past and present (*time*); visuals especially photographs used to portray *truth* including scientific imagery, NGO visuals, and television documentaries; and finally, particular types of visual imagery manifests power for some and not for others, i.e., promote ways of conceptualizing climate change, while marginalizing others. In terms of the 3D VR visualizations for climate change, O'Neill & Smith (2013) highlight that "3D landscapes visualizations add a vivid virtual reality element to climate projections, enabling participants to immerse themselves and interact in a dynamic 'fly through' experience of photorealistic imagery of local landscapes visualized under future climate scenarios," p. 16. In their critical review, O'Neill & Smith (2013) also highlight that such climate change VR visualizations have represented land-use change in various geographical landscapes, including agricultural, coastal zone management, mountain snowpack depletion, and flood management. O'Neill & Smith (2013) also highlight in their critical review that participants positively evaluate such visualization experience and find the scenarios credible, adding that there such visualization of climate change increases self-assessed knowledge of both climate mitigation and adoption.

In the context of VR news and climate change, Barnidge et al. (2021) highlight that news organizations are increasingly utilizing VR to produce immersive journalism content in their study exploring the effects of VR news on learning about climate change. And to test whether VR news can be an effective tool for learning about climate change, Barnidge et al. (2021), based on a controlled in-person laboratory experiment, compared VR news stories to 360-degree video and text with images versions of news and found no main effects on the learning outcomes. Barnidge et al. found the indirect effect of VR news on cognitive elaboration via cognitive absorption, which suggests that immersive VR may work best as a learning tool when it influences cognitive rather than affective pathways.

Oh et al. (2020), in their study on how 360-degree video influences content perception and environmental behavior, conducted a lab experiment involving 76 participants to compare pro-environmental 360-degree videos and unidirectional videos in their persuasive effectiveness. Oh et al. found that 360-degree features in videos can be effectively conceptualized as a form of modality interactivity, and those features can potentially adjust users' behavioral intentions. Oh et al. also contend that "more entertaining, engaging immersive experiences enabled by the 360-degree feature was capable of enhancing participants' intentions to protect the environment," (Oh et al., 2020, p. 443).

Further, Ahn (2011), in their study on embodied experiences in immersive virtual environments, explored the effects on pro-environmental attitude and behavior – where the participants in two experimental conditions embodied the experience of cutting down a redwood tree as a result of using non-recycled paper products. Ahn (2011) observed an increase in pro-environmental self-efficacy or the belief that their individual actions could improve the quality of the environment. Similarly, in their study, Smit et al. (2021) explored the uses of VR to stimulate healthy, environmentally friendly food consumption among children. Using a VR experience and semi-structured interview as methodology, Smit et al. found that all participants were able to recall the information about the impact of food products on their health and the environment. When the participants understood the information, they were often aware of and felt sorry for their negative behavioral impact and expected their behavior to positively change when imagining the real-life application of the VR experience.

Framing of Climate Change Messages and its Effects on People
An increasing body of work highlights that media framing climate change issues have profound impact/effects on the people and communities at large (Schäfer & Schlichting, 2019; Midttun et al.,

2015). Many scholars, including Shehata & Hopmann (2012), argue that news framing and issue-framed news have mobilizing effects. Furthermore, other studies show that frames and visuals affect audiences' criticism of governmental bodies and identification with a movement (Kilgo & Mourão, 2021). Studies have also explored framing the climate change messages as either positive or negative and its effects on people's behavior. Nelson et al. (2020), in their study exploring the use of VR as a tool for environmental conservation and fundraising, conducted a field experiment to investigate the effects of varying degrees of visual immersion and positive and negative framing on people's contributions to a conservation charity. Using a five-minute video on the coral reefs and the need to protect such underwater ecosystems, Nelson et al. conducted an experiment with 1006 participants involving VR HMD and compared the same effects of the immersive content with unidirectional film. The findings from Nelson et al.'s study show that 360-degree video film with a negative message garnered significantly larger average donation amounts compared to the unidirectional film. Nelson et al. contend that VR is an effective way to raise awareness of environmental threats and encourage behavioral action among people.

Similarly, Ahn et al. (2015), in their study on framing virtual experiences, explored the effects on environmental efficacy and people's behavior over time. Using gain and loss-framed environmental messages as virtual experiences, Ahn et al. found that the participants immediately after exposure to the virtual experience promoted environmental behavior by reducing paper consumption by 25% compared to a control group. Furthermore, Ahn et al. found that the gain-framed experience of growing a virtual tree promoted behavioral intentions more effectively than the loss-framed experience of cutting down a tree. The researchers also found that the participants in high interactivity conditions reported higher levels of environmental behavior than those in the low interactivity conditions one week following the exposure. Ahn et al. conclude that "even a brief framed experience in virtual environments can be powerful enough to persist and change actual behavior in the physical world, the outlook of such an application is encouraging," (Ahn et al., 2015, p. 859).

Other studies, though not involving VR as a method of examination, have also explored the importance of content or the messages around climate change to understand its effects on people. Studies such as Kotcher et al. (2021) explored the effects of messages about health consequences of climate change and found that advocacy messages are more effective when they include information about the risks (such as impacts of climate change on air quality), solutions (transition to clean energy their benefits to people's health) and a normative appeal (that most Americans support this solution and are taking action to advocate for it). Kotcher et al.'s study tested the motivational value of three categories of climate information, namely: (1) health consequences of climate change, (2) health benefits of climate solutions, and (3) calls-to-actions intended to motivate people to engage in political advocacy for solutions to climate change. They found that all three categories of climate information enhanced the overall motivational value of the message, and that climate solutions information was the most influential. Similarly, Harrison et al. (2020) also explored framing climate change and health.

Taking a qualitative thematic analysis of climate change and health media coverage in two online news outlets in New Zealand, Harrison et al. explored how the issue of climate change was framed and how it may be framed more effectively to encourage climate action. Harrison et al. found that both the online news outlets emphasized the threat climate change poses to health, which overshadowed the positive health opportunities of climate action. On a similar note, Ford & King (2015), in their study, explored coverage and framing of climate change adaption in the media and found that of the 271 newspaper articles (between 1993 and 2013) with adaption content, the majority, about 53% focused on stating the need to adapt as opposed to documenting actual preparations being undertaken for adaption or actual adoptions that have taken place. Ford & King (2015) also looked at the role of IPCC in stimulating adoption reporting and found no reference to the third assessment of the IPCC climate change report (2001), and that there was no associated increase in reporting on climate change adaption in the year 2001. However, Ford & King also found the first surge in adaptation reporting in 2007 and contend that it is partly a function of the release of the IPCC AR4 climate change report, which provided the framing for a quarter of the adaptation articles in 2007.

The review of literature for this study has offered critical insights from both areas (1) examining the affordances, uses, and effects of VR in climate change storytelling, and (2) framing of climate change messages in traditional and VR mediums and its effects on people. The literature review clearly shows how VR has become an important tool/immersive medium to create awareness, empathy, self-efficacy, positive attitudes towards the environment, and educate people about the climate crisis and its effects on human health and its impact on biodiversity. The literature review has also offered insights on the importance of framing climate change due to the mobilizing effects. Further, it is important to highlight the critical argument that scholars such as Markowitz & Bailenson (2021) raise that, "it is time to no longer discuss the potential of VR, but instead to focus on how to scale its uses effectively and responsibly," p. 60. Markowitz & Bailenson further highlight that innovative experiential approaches to teach climate change effects are required to modify attitudes supporting pro-environmental actions.

Meanwhile, it should be noted that popular social media platforms such as Facebook (which also owns immersive VR platforms like Oculus TV and produces wearable HMD's such as Quest 2 with haptics controllers, etc.) have in the recent past described the future of social media as the metaverse a.k.a three-dimensional internet (i.e., a surround-yourself technology where social network brings to life in 3D environment with the use of AR, VR, and mixed reality) and even changed the name of the parent company *Facebook Inc* to *Meta Platforms Inc* or Meta for short. The founder Mark Zuckerberg described the new meta platforms as a "virtual environment where you can go inside of, instead of just looking at on a screen. People can meet, work, and play, using virtual reality headsets, augmented reality glasses, smartphone apps or other devices" APNews (2021).

In this regard, considering the transformational storytelling nature of VR (as highlighted in the above literature review) and the limited scholarly work – particularly content analysis of VR media productions to understand how they utilize EM, the current study seeks to address the gap in the literature by further exploring this phenomenon from a qualitative standpoint and by adopting experiential media theoretical model and IPCC framework on climate change. The current study seeks to investigate the following research questions:

RQ1: To what extent do the VR media productions pertaining to climate change on Oculus TV utilize six qualities of experiential media?

RQ2: What themes do such VR media productions highlight pertaining to climate change?

RQ3: To what extent do the themes identified from the VR media productions capture key points highlighted by the landmark IPCC 2018 special report on framing or contextualizing climate change from a multidisciplinary approach?

METHOD

This study involves a mixed methodology approach, including the use of (a) qualitative content analysis technique with insights offered by Charmaz (2014) for the investigation of VR media productions; (b) use of experiential media (EM) theoretical model that provides a framework to understand the six primary qualities of the virtual environment namely: *(1) interactivity, (2) immersion, (3) multisensory presentation, (4) algorithm and data, (5) first-person perspective, and (6) natural user interface.*

The application of EM theoretical model also helps us understand how EM is transforming the role of the audience to be more of an active user who experiences stories as a participant rather than an audience member who tend to passively watch, listen or read the narrative from a third-person's perspective i.e., how experiential media enables the user not just to experience the medium, but also to participate or engage in a story or content itself; and finally (c) the use of United Nation's inter-governmental panel on climate change (IPCC 2018) special report's framework on climate change, where the report particularly the *Chapter 1* offers insights on how to frame and contextualize climate change from a multidisciplinary approach including both cause and effects such as poverty, hunger, health and well-being, inequality, social justice, socio-cultural, socio-technical, socio-economic, institutional, governance, education, clean water and sanitation, industry and infrastructure, consumption and production, agricultural management, social-ecological systems, indigenous knowledge systems, etc., in addition to framing climate change as CO_2 emissions, global

warming, rising sea levels, loss of biodiversity, extreme weather events, droughts, acidification, coral reefs bleaching, lack of environmental protection, etc.

In terms of the use of research tools, the current study involved the use of Oculus Quest 2, an advanced VR HMD with two haptic controllers and 3D positional audio to observe and experience the VR media productions on Oculus TV, a VR application. It can be noted that in terms of the pros, Meta's Oculus Quest 2 is one of the popular VR HMDs (with access to the Oculus TV VR application) and is rapidly diffusing technology worldwide, with as many as 10 million units sold since its launch (Gartenberg, 2021). In terms of technical features, the Oculus Quest 2 VR HMD (weighing around 17.7 ounces) offers accurate head tracking with the use of four cameras with built-in sensors to track users' orientation; use of higher resolution monitors with 1,832 by 1,920 resolution per eye and a 90Hz refresh rate for sharper and realistic visuals and seamless VR experience (Greenwald, 2021). In terms of the cons, the technology can cause users to get addicted to the virtual world and might cause VR sickness.

Meanwhile, the data for the current study were gathered using multiple steps, including **Step 1:** Identifying the VR media productions pertaining to climate change on Oculus TV; **Step 2:** observe, experience VR media productions, and record data in the form of memos on the extent to which such VR media productions pertaining to climate change on Oculus TV utilize six qualities of experiential media; **Step 3:** observe and experience VR media productions for the second time, and record data in the form of memos identifying dominant themes highlighted by such VR media productions pertaining to climate change; and **Step 4:** compare the recorded themes from the Step 3 with the key points highlighted by the landmark IPCC 2018 special report's framework to identify to what extent the VR media productions themes resonate IPCC's insights on framing and contextualize climate change from a multidisciplinary approach. The study was conducted during September and November 2021.

FINDINGS AND DISCUSSION

Identifying the VR Media Productions

As part of *Step 1* to identifying the VR media productions pertaining to climate change on Oculus TV, a search with a combination of keywords including climate; climate change; conservation; wildlife conservation; biodiversity; extinction, and forest fire; climate crisis; global warming; raising sea level; carbon emission; forest loss; deforestation; natural disasters; marine pollution; water pollution; air pollution; famine; drought; and hunger crisis resulted in a total of only nine VR media productions (as illustrated in Table 1).

Table 1. List of nine VR media productions from Oculus TV

Title of the VR Content Production	Year of Production	Length VR Production	Produced by
Fly Over Ireland in 360	March 25, 2017	4:06 mins	CNN
Into the Himalayas: VR	April 25, 2020	3:04 mins	UNDP and MoEF Govt of India
Visiting the Island of Seabirds an Uninhabited Remote Wildlife Refuge in American Samoa	May 16, 2020	4:48 mins	PBS Newshour
Walking the Florida Wildlife Corridor with Carlton Ward Jr	August 7, 2019	6:18 mins	PBS
In the Shadow of Orangutan	June 19, 2019	9:52 mins	Canopi VR and Borneo Adventure
Walking with Scientists | 360 VR | Fieldwork Showcase	September 11, 2020	4:59 mins	Department of Environment, Land, Water & Planning Victoria
Rodale Institute Virtual Tour Biodiversity	December 16, 2020	1:22 mins	Rodale Institute
The World's Smallest Whale on the Brink of Extinction in the Sea of Cortez	February 20, 2020	1:03 mins	ABC 10 News San Diego -KGTV
Fighting Forest Fires with Pilot of the Spanish Air Force	April 12, 2019	3:59 mins	EU Civil Protection and Humanitarian Aid Operations (ECHO)

Analysis of VR Media Productions

As part of the **Step 2, Step 3 and Step 4** all the nine VR media productions were observed/experienced. Following is the analysis of the VR media productions based on the data gathered in the form of memos.

Fly Over Ireland in 360

Fly over Ireland in 360 is a 4.06 mins long VR media production produced by CNN Travel on March 25, 2017. The VR film takes the user to an otherworldly landscape often known as the 'land of fire and ice' where Iceland (located in the Atlantic between the United States and Europe) with massive ice caps sits atop active volcanoes. The VR film offers multiple 360-degree views of the massive glaciers melting, indicating that the region is a 'ground zero for climate change' and that the landscape will lose much of its ice cover within a generation or two. Taking a narrative driven approach of storytelling, the VR film attempts to put the user in a first-person perspective where the bird's-eye view allows the user to experience the narrative as if they are in Iceland witnessing the devastating impact of climate change on the island nation.

The narration in the background offers insights into the developments that led to such a situation, including the use of the massive amount of fossil fuels such as coal, oil, and natural gas, which caused the pollution to be trapped in the atmosphere and gradually warming the planet and melting the pristine ecosystems in Iceland. The VR film captures the past IPCC report highlighting of global warming of 1°C since the industrial revolution and in the Arctic region, about twice as much, i.e., around 2°C. The VR film also highlights the impact of such an increase in the temperatures on glaciers such as Svínafellsjökull Glacier in Iceland and the formation of glacier lakes due to massive ice melt. The VR film also takes the user on a journey to the consequences of melting glaciers beyond the island country – i.e., the global sea-level rise causing many low-lying countries and cities to submerge. The VR film also highlights how the water from the glacier lakes courses down rivers and into the sea along the way through natural ecosystems such as Gullfoss Waterfall and Thingvellir National Park. The VR journey ends at a geothermal spa, popularly known as the Blue Lagoon, a man-made feature using sustainable energy that hints at a solution to the climate crisis.
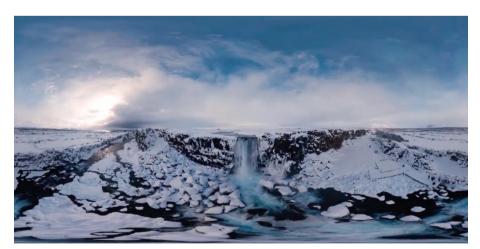

Figure 1. Screenshot from "Fly over Ireland in 360" VR media experience (*source:* Research doc.)

Into the Himalayas: VR

Into the Himalayas: VR is a 3.04 mins long VR media production produced by the United Nations Development Programme (UNDP) in collaboration with the Ministry of Environment, Forest and Climate Change (MoEF) Government of India on April 25, 2020. The VR media production takes the user on a virtual journey to the largest mountain range in the world, the Himalayas – which is home to an astonishing range of wildlife species. The VR experience utilizes real-world 360-degree

visuals of a wide range of ecosystems in the Himalayas and offers a glimpse of wildlife habitats, treacherous terrains, and the lives of the people dwelling in the mountain region.

The immersive journey is in first-person perspective, and the user is guided with text (that is overlayed on the 360-degree visuals) to remind people to look around and explore the wildlife (including a close encounter with the critically endangered Himalayan snow leopard), and the remote places where people are seen living in harmony with nature in the Himalayan Mountain region. The use of breathtaking 360-degree visuals and 3-D ambiance sound of water, wind, wildlife, and the Buddhist monks chanting together offers a truly compelling immersive journey of the mighty Himalayas. While the VR media production highlights the uniqueness of the Himalayan Mountain region and offers a 360-degree perspective to understand the importance of such ecosystems, the immersive experience, unlike the *Fly Over Ireland in 360 VR experience,* offers limited insights on the impact of climate change on the Himalayan biodiversity.

Figure 2. Screenshot from the "Into the Himalayas" VR media experience (*source:* Research doc.)

Visiting the Island of Seabirds an Uninhabited Remote Wildlife Refuge in American Samoa

Visiting the Island of Seabirds, an Uninhabited Remote Wildlife Refuge in American Samoa is a 4.48 mins long VR media production produced by PBS Newshour on May 16, 2020. The immersive content utilizes a narrative-based approach and offers users an opportunity to join the PBS NewsHour team to visit the remote (southernmost point in the United States) region of Rose Atoll and explore how the uninhabited wildlife refuge in American Samoa is being impacted by climate change. The immersive journey, which is guided by a voiceover of one of the PBS NewsHour journalists, starts with users virtually experiencing a glimpse of the eight-hour boat ride from Pago Pago - Capital of American Samoa towards the tiny (about 16 acres of land) Rose Atoll also known as Motu O Manu (in Samoa) or the island of seabirds, followed by a virtual exploration of the Rose Island and its surroundings including the sand island.

The VR experience highlights how the tiny place with the reef is critical to the entire region of the South-Central Pacific Ocean – as over 90 percent of American Samoa's seabirds nest in the tiny Rose Atoll, which is closed to the general public and can only be accessed with special permission from the US Fish and Wildlife Service. The 360-degree visuals of the island and its biodiversity, including seabird colony where hundreds of Sooty Tern, Red-Footed Booby, Red-Tailed Tropicbird, Black Noddy birds, and other species such as Strawberry Hermit Carb. The use of 3-D ambiance sound throughout the immersive journey, including the sound of the Sooty Tern chicks and Black Noddy chicks calling their parents to return with food, makes for a compelling, immersive experience. The immersive journey also highlights the importance and success stories of wildlife conversation at the Rose Atoll, including the US Fish and Wildlife Service's work in eradicating the invasive rats and control of the coconut trees that uses limited freshwater in the tiny island, which is critical for the local trees such as Pisonia that offers shelter for the seabirds. The VR media production also highlights the current climate change-related projects, including monitoring the impacts of the sea-level rise on the tiny four-acre sand island, which is a resting site for the seabird in the Rose Atoll.

Figure 3. Screenshot from "Visiting the Island of Seabirds an Uninhabited Remote Wildlife Refuge in American Samoa" VR media experience (*source:* Research doc.)

Walking the Florida Wildlife Corridor with Carlton Ward Jr

Walking the Florida Wildlife Corridor with Carlton Ward Jr is a 6.18mins long VR media production produced by PBS on Aug 7, 2019. In this immersive experience, the users are invited to join the conservation photographer Carlton Ward Jr to explore the Florida wildlife, including unseen, overlooked, and forgotten wildlands by much of the Florida state. The VR content production through narration highlights the importance of the Florida wildlife corridors and the need to keep such wild lands connected, as without the wildlife corridors connecting those wild places, the wildlife that lives there will not have the room they need to survive. The immersive content production offers the user an opportunity to experience such wildlife corridors, including Audubon's Corkscrew swamp – the largest old-growth (including many trees over 500-years in age and around 100feet tall) cypress forest in Florida. The placement of the 360-degree camera in the core area of the cypress forest, along with the ambiance sound of the forest, offers a truly immersive experience of the critical wildlife habitat, which is home to many species of wildlife, including black bears, panthers, bobcats, white-tailed deer, fish, wading birds, alligators, and otters.

The user also gets to experience another similar habitat, i.e., South Florida's Pond-apple/Pop ash Slough; unlike the tall cypress forest, the trees in such ecosystem are lower to the water, and their twisted and gnarled trunks are host to the highest diversity of epiphytes, bromeliads, and orchids that exist in all of North America. The VR experience also highlights some statewide conservation programs to keep all the wildlands connected, including the wildlife underpass beneath Interstate 75 in Florida, which connects Picayune Strand State Forest in the South, and Florida Panther National Wildlife Refuge in the North. Such wildlife underpasses with chain-linked fences keep the animals off the busiest interstate and funnel them to below safe passage.

The immersive content production also uses still photographs overlaid on the 360-degree video to show users some camera trap images of the animals using such an underpass as a safe passage. The immersive experience also offers insights into how the camera traps (including infrared tripwires or laser beams) are set up to monitor wildlife and its habitat. The VR experience ends with the importance of preserving and protecting such critical wildlands, which are the key parts of the Florida Wildlife corridor, as they ensure the health of the Everglades watershed, the estuaries downstream, and to the people who rely on drinking water, and failure to keep the lands connected could lead to the detriment of wildlife and people.

Figure 4. Screenshot from "Walking the Florida Wildlife Corridor with Carlton Ward Jr" VR media experience (*source:* Research doc.)

In the Shadow of Orangutan

In the shadow of orangutan is a 9.52 mins long produced VR media production produced by Canopi VR and Borneo Adventure on June 19, 2019. The immersive content takes the user on a journey inside the Batang Ai National Park in Sarawak, Malaysia, one of the last secure habitats for endangered orangutans. The immersive experience invites the user to join the local tour guide and a group of adventure travelers in search of wild orangutans. The journey starts with a long drive on the road and then on a boat towards Nanga Sumpa Longhouse at Batang Ai, where increased sightings of the endangered orangutans were reported. While in search of the great apes, the user gets to experience the rich folk tradition and lifestyle of the Iban tribes – who live among the boughs and branches of the jungle.

The narrative style transitions to the second-person point of view where an Iban tribal senior can be seen explaining orally to their tribal children in a traditional folk storytelling method the importance of protecting the orangutans. The scene transitions to an artistically created immersive narrative that captures the Iban's rich folklore that illustrates orangutans as their family members. The immersive content then puts the user back with the team in the jungle of Batang Ai-Lanjak Entimau landscape in search of the orangutans. Overall, the VR media production highlights how in addition to the Iban's traditional beliefs as Orangutans as their family, the partnerships between sustainable tour operators, conservation projects, and Iban's traditional knowledge has helped protect the Batang Ai-Lanjak Entimau landscape, which is the critical orangutan habitat with around 95% of the 1600 orangutan in Sarawak.

Figure 5. Screenshot from "In the Shadow of Orangutan" VR media experience (*source:* Research doc.)

Walking with Scientists - Fieldwork Showcase

Walking with Scientists - Fieldwork Showcase is a 4.59 mins long VR media production produced by the Department of Environment, Land, Water & Planning Victoria, Australia, on September 11, 2020. The VR media production invites the user to experience what it's like to be a field scientist at the Arthur Rylah Institute (ARI) in Victoria, Australia, explore the wetlands, search for endangered species, and survey birds on the remote islands. The journey starts with a wetland invertebrates survey where the scientists look at how productive the wetland ecosystem is in terms of the high abundance of life.

The immersive journey transitions to brief virtual experience of electrofishing on the Murray Codfish (a large Australian predatory freshwater fish) followed by a survey of birds, turtles, greater glider (gliding marsupials), southern Bent-wing bat, the river vegetation, and finally a brief experience of the post-fire ground-truthing. The VR content production also highlights other critical species in the ecosystem, such as striped legless lizard and Eels, including trapping and satellite tagging of Eels, and exploring the behavior of Dandenong Burrowing Crayfish – which can be seen playing dead when disturbed. Back in the laboratory, the user can briefly experience some scientific tasks performed, including Otolith or fish ear bone analysis.

Figure 6. Screenshot from "Walking with Scientists - Fieldwork Showcase" VR media experience (*source:* Research doc.)

Rodale Institute Virtual Tour Biodiversity

Rodale Institute Virtual Tour Biodiversity is a 1.22 mins long VR media production produced by Rodale Institute on December 16, 2020. The immersive content offers users a first-person point-of-view experience of the institute's 333-acre experimental organic farm in Kutztown, in Berks County, Pennsylvania. The immersive experience offers insights into the concept of organic farming – where it is not just about avoiding the use of chemicals such as pesticides or herbicides or use of genetically modified organisms (GMO), but organic and regenerative agriculture, in addition to the above, is mainly about farming with nature. Throughout the VR experience, the user gets to witness the biodiversity in and around the organic farm, including different plants and animals, and highlights various farming practices, including apiculture or beekeeping. Overall, the VR content highlights that every living thing plays a role and keeps the system in balance. Hence it is important to farm with nature.

Figure 7. Screenshot from "Rodale Institute Virtual Tour Biodiversity" VR media experience (*source:* Research doc.)

The world's smallest whale on the brink of extinction in the Sea of Cortez

The world's smallest whale on the brink of extinction in the Sea of Cortez is a 1.03 mins long VR media production produced by ABC 10 News San Diego - KGTV on February 20, 2020. The VR content production uses only a news reporting style narrative where the user can see the journalist from the ABC 10 news interviewing a conservationist (both onboard a boat) to seek insights on the current status of the Vaquita, the world's smallest whale on the brink of extinction in the Sea of Cortez. The VR media production highlights the importance of the conservation of the species and its habitat (Sea of Cortez in the Upper Gulf of Baja California) as it is the only place on earth where the elusive porpoise (known as the Panda of the sea) are found. In terms of the threats posed to the Vaquita whales, the VR production highlight the primary reason for illegal fishery operated by organized criminals – as they set up nets to catch the Totoaba, a large fish about the size of Vaquita, and accidentally end up catching the Vaquita thereby bringing elusive porpoise closer to extinction. The VR content production ends with a message that unless the governments etc., can get a handle on the illegal fishery, the Vaquitas are going to continue towards extinction point and that there is a need to get our arms on the issue and policies to make sure the Vaquita has a future.

Figure 8. Screenshot from "The world's smallest whale on the brink of extinction in the Sea of Cortez" VR media experience (*source:* Research doc.)

Fighting forest fires with pilot of the Spanish Air Force

Fighting forest fires with the pilot of the Spanish Air Force is a 3.59 mins long VR media production produced by the European Union Civil Protection and Humanitarian Aid (ECHO) on April 12, 2019. The VR experience opens with a view from inside the cockpit or flight deck, where the Spanish Air force pilots can be seen preparing for an exercise mission in preparation for real emergencies during forest fires. While onboard the water bomber plane, the VR experience, besides offering multiple

perspectives of the forests (that are prone to forest fires) from the air, also includes voiceover that adds insights on how in summer months, due to little rain, high temperatures followed by strong winds causes the forest fires to spread rapidly and becomes a real challenge for the firefighters on the ground to control and mitigate the same. Hence, the VR content highlights the importance of firefighting planes, which is essential to save people's lives and their homes – where some countries alone cannot handle the extent of the forest fires and depend on other countries for help in extinguishing the importance of the ECHO project.

The VR experience also offers insights on disaster management by ECHO, such as rescuing people from floods, earthquakes, other natural disasters, or when there is an outbreak of a disease – where the VR production highlights the EU Civil Protection mechanism that pulls together trained experts and resources from all participating countries in the EU. The VR experience then transitions to the actual exercise mission where the user can witness (thanks to the placement of the 360-degree camera on the plane wings) scooper planes filling water from a nearby river where the planes can be seen filling water around 6000 liters of water in less than 12 seconds. The scene transitions to the pilots releasing the water in the nearby forest (where a patch of controlled land can be seen set on fire for exercise purposes) to prevent the fire from spreading, thereby successfully extinguishing the forest fire and returning to the home base after the exercise mission.

Figure 9. Screenshot from "Fighting forest fires with pilot of the Spanish Air Force" VR media experience (*source:* Research doc.)

Finding pertaining to RQ1 (EM qualities utilized by VR media productions)

The observation of the nine VR media productions pertaining to climate change on the Oculus TV platform revealed that the VR productions made limited use of six qualities of EM, i.e., *(1) interactivity, (2) immersion, (3) multisensory presentation, (4) algorithm and data, (5) first-person perspective, and (6) natural user interface.* Across all the nine VR media productions, the two main qualities observed were *immersion* and *first-person perspective*, i.e., the VR media production offered envelopment with the story through 360-degree imagery. For instance, the *Fly Over Ireland in 360* VR media production offered 360-degree imagery of Iceland's melting glaciers – where one has the ability to look around the landscape, in this case melting glaciers, and experience the phenomenon first hand. However, in terms of the freedom of movement in such virtual environments, though the contents were VR media production on Oculus TV, all the nine immersive experiences offered limited degrees of freedom (DoF) of movement as opposed to the full-VR experience offering six DoF where the user not only look about in all directions but also to move about in a 3D virtual space or environment. In terms of the *multisensory presentation quality*, all the nine VR media productions utilized lifelike *sight* as if the users were present either in the Himalayas experiencing biodiversity or in uninhabited remote wildlife refuge in American Samoa.

Similarly, the nine VR media productions offered a 3D environment through *sound* as a sensory experience where ambiance sound offers an opportunity to increase the sense of presence, for example, the ambient sounds of the Audubon's Corkscrew swamp, which is the largest old-growth cypress forest in Florida, or the calls of the orangutan in Batang Ai-Lanjak Entimau landscape in

Sarawak, Malaysia. However, the observation of the VR media productions revealed limited use of *haptics* (touch) as part of the immersive experience. The sense of touch through haptic controllers (an accessory that comes with the HMD) was experienced only while accessing the VR media production on the Oculus TV platform, such as to pause, play, forward, and rewinding the immersive content – a *natural user interface* EM quality that helps users control and navigate the immersive content and such *natural user interface* (NUI) interface also include voice commands to control the HMD. However, the actual content productions do not incorporate haptic feedback, voice commands, or engagement as part of narrative storytelling. Further, all the nine VR experiences lacked the qualities of *interaction,* and *algorithm and data* as they offered no exchange between the user and the content experience – including the lack of embedded content to navigate layered elements of a story; use of data-driven features, eye-gaze based interaction or any engagement with the content using the algorithm.

Finding pertaining to RQ2 (dominant themes highlighted by VR media productions)
In terms of the findings from the thematic analysis, five major thematic categories (global warming; biodiversity and endangered species; culture and traditions; conservation and disaster management; and agriculture) and various sub-themes, as illustrated in *Table 2,* were identified from observations and memos from all the nine VR media productions. The VR media productions predominantly focused on biodiversity and endangered species such as the Himalayan range and its species such as Snow Leopard, mountain ibex, and so on; uninhabited wildlife refuge in American Samoa, which is home to Sooty Tern; Red-Footed Booby; Red-Tailed Tropicbird; Black Noddy birds; Strawberry Hermit Carb; Pisonia trees - shelter for the seabirds and so on; Florida wildlife cypress forest that provides habitat for the critically endangered panthers and other wildlife such as black bears; bobcats; white-tailed deer; fish; wading birds; alligators; otters; Batang Ai National Park in Sarawak home to endangered orangutans; wetlands ecosystem and the biodiversity in Victoria, Australia home to Murray Codfish; turtles; greater glider (gliding marsupials); southern Bent-wing bat; striped legless lizard; Eels; Dandenong Burrowing Crayfish; Sea of Cortez home to critically endangered Vaquita whales also known as the Panda of the sea and so on.

The VR media productions also highlighted various conservation and disaster management projects such as Blue Lagoon, a man-made feature utilizing sustainable energy; controlling of invasive species; wildlife underpass that offers safe passage for wildlife, the importance of camera traps, infrared tripwires, or laser beam to document wildlife movement and behavior; conservation of drinking water; glimpses of wetland invertebrates survey; the importance of sustainable tour operators; electrofishing technique and satellite tagging; fighting forest fires using water bomber planes; exercise missions for disaster preparedness or emergency situations including rescuing people from floods, earthquakes, other natural disasters including the outbreak of a disease.

The thematic analysis also revealed some insights on the theme of global warming, the role of indigenous culture and traditions, and agriculture. For the global warming thematic category, various sub-themes such as melting glaciers; sea-ice melt; glacier lakes; sea-level rise; Iceland as ground zero for climate change; fossil fuels - coal, oil and natural gas; industrial revolution; Arctic region; drought-like conditions; high temperatures; strong wind; extreme weather events; forest fires and wildfires were identified. Similarly, sub-themes for the thematic category on agriculture include water conservation; organic farming; chemicals; pesticides; herbicides; genetically modified organism (GMO); regenerative agriculture; farming with nature; farming practices; apiculture or beekeeping; illegal fishery were identified. The VR media productions also briefly gave importance to culture and traditions, including the Himalayan Buddhist monks, chants, monasteries; Iban tribes in Malaysia, folk stories and songs, traditional lifestyle, and the importance of Iban's traditional knowledge in protecting the critical orangutan habitat.

Table 2. Overall themes grouped under five categories (global warming; biodiversity & endangered species; culture and traditions; conservation and disaster management; and agriculture) identified from observations and memos from all the nine VR media production

Global Warming	Biodiversity & Endangered Species	Culture and Traditions	Conservation and Disaster Management	Agriculture
Land of fire and ice; Glaciers melting; sea-ice melt; glacier lakes; sea-level rise; Iceland - ground zero for climate change; fossil fuels - coal, oil and natural gas; industrial revolution; Arctic region; drought-like conditions; high temperatures; strong wind; extreme weather events; forest fires and wildfires	Pristine ecosystems; wildlife habitats; Himalayan Snow Leopard; Himalayan mountain ibex; Himalayan mountain range; natural ecosystems - Gullfoss Waterfall; Thingvellir National Park; Rose Atoll; American Samoa; uninhabited wildlife refuge; South-Central Pacific Ocean; Sooty Tern; Red-Footed Booby; Red-Tailed Tropic bird; Black Noddy birds; Strawberry Hermit Carb; Pisonia trees - shelter for the seabirds; Florida wildlife; Audubon's Corkscrew swamp; cypress forest; black bears; panthers; bobcats; white-tailed deer; fish; wading birds; alligators; otters; South Florida's Pond-apple/Pop ash Slough; epiphytes; bromeliads; orchids; Picayune Strand State Forest; Florida Panther National Wildlife Refuge; Everglades water shed; estuaries; Batang Ai National Park in Sarawak; Nanga Sumpa Longhouse; orangutans; Batang Ai-Lanjak Entimau landscape; critical orangutan habitat; biodiversity in Victoria, Australia; wetlands ecosystem; Murray Cod fish; turtles; greater glider (gliding marsupials); southern Bent-wing bat; river vegetation; striped legless lizard; Eels; Dandenong Burrowing Crayfish; Sea of Cortez; Vaquita whales - Panda of the sea; Totoaba fish	Himalayan Buddhist monks; Buddhist chanting; Buddhist monasteries; Iban tribes; folklore; folk stories; Iban tribes' tradition and lifestyle; Iban's traditional knowledge	Man-made features - Blue Lagoon; sustainable energy; controlling invasive species; Florida wildlife corridors; wildlife underpass; chain-linked fence; safe passage; camera traps; infrared tripwires or laser beam; drinking water; wetland invertebrates survey; sustainable tour operators; electrofishing; satellite tagging; Otolith or fish ear bone analysis; Fighting forest fires; water bomber planes; exercise missions for emergency situations; rescuing people from floods, earthquakes, other natural disasters including the outbreak of a disease	Water conservation; organic farming; chemicals; pesticides; herbicides; genetically modified organism (GMO); regenerative agriculture; farming with nature; farming practices; apiculture or beekeeping; illegal fishery

Finding pertaining to RQ3 (framing and contextualization of climate change)

In terms of the RQ3, the findings showed that most of the immersive content productions explored in this study offered limited insights into the direct and indirect threats posed by human-induced climate change on wildlife and people. In this regard, the observation showed that the VR media productions utilized limited framing and contextualization of climate change and multidisciplinary approach or standpoint. For instance, the Orangutan VR production offers limited insights on the effects of deforestation, its impact on the habitat and other wildlife species, and only briefly highlights the role of Iban's traditional culture in protecting orangutans and the economic success of Iban tribes due to the collaboration with the sustainable tourism industry. It should be noted that poaching and loss of forest cover due to the illegal encroachment of forest lands for plantations etc. are the primary cause of threat to the local biodiversity, especially Orangutans, and such loss of forest, including wildlife and its habitats and other natural resources can be seen in turn fueling the global climate crisis (Zander et al., 2014). Further, the findings also show that the nine VR media productions lacked highlighting the key environmental issue, i.e., marine plastic pollution that has

already contaminated world's ocean and yet continues to lack global efforts to mitigate the problem (Megan & Noer, 2020).

Considering the powerful role of VR in increasing pro-climate behavior and action, as highlighted in the review of literature, the findings further highlight that there is a need to frame and contextualize the issues from a multidisciplinary approach for both cause and effect. The IPCC 2018 special report on climate change offers detailed insights on how to frame and contextualize the narrative on climate change, including but not limited to focus on eradicating poverty, hunger, health and well-being, inequality, social justice, socio-cultural, socio-technical, socio-economic, institutional, governance, education, clean water and sanitation, industry and infrastructure, consumption and production, agricultural management, social-ecological systems, indigenous knowledge systems, CO_2 emissions, global warming, rising sea levels, loss of biodiversity, extreme weather events, droughts, acidification, coral reefs bleaching, and lack of environmental protection.

Discussion and Theoretical Contribution

The study offers implications for immersive storytelling on climate change for developers and immersive platform providers on multiple fronts. To start with, the literature review on the uses of VR in climate change storytelling has clearly shown how VR as an immersive media technology can bring behavioral changes, demonstrate knowledge gains about the climate crisis and increase climate action. The findings from the current study offer some insights into the quality and quantity of the VR media productions on Oculus TV, a popular VR media platform. In terms of the quantity, surprisingly, only a total of nine VR media productions were found pertaining to climate change issues, despite the worldwide debate and movement on climate change, including extensive news reporting on climate emergency and the 'call to immediate action' from across worldwide leaders and organizations including the United Nations.

Further, considering the important role of VR as a powerful tool for climate change storytelling, as highlighted in the review of the literature section and the fact that Meta Platforms Inc (who also owns the Oculus platform and produces hardware) attempts to put their immersive technologies at the forefront as the leading immersive and interactive media and communication platform provider, there is a need for more VR media productions pertaining to climate change issue on Oculus TV. However, it should also be noted that though the VR media productions on climate change were limited in numbers, the current content productions focused on stories from remote parts of the world, from the Himalayan region in Asia to Iceland in the Arctic region. Further, in terms of the quality, the current study has offered some insights on the nine VR media productions, including the limited use of EM qualities by the VR content productions, limited framing and contextualization of the issues around climate change, and lack of multidisciplinary approach – all of which are key to understanding and mitigating the climate crisis.

Overall, the VR media productions offered immersive experiences of the wildlife and wild places in some of the world's remote corners and highlighted the need to preserve and protect such natural wonders. The VR productions also offer hope by portraying success stories of conservation projects such as Florida Wildlife Corridors and the use of wildlife underpasses etc.

CONCLUSION

In conclusion, the findings revealed that all the nine VR media production utilized limited qualities of EM, i.e., *(1) interactivity, (2) immersion, (3) multisensory presentation, (4) algorithm and data, (5) first-person perspective, and (6) natural user interface.* The findings also revealed five broad thematic categories, including global warming; biodiversity & endangered species; culture & traditions; conservation & disaster management; and agriculture, along with various sub-themes identified from all the nine VR media productions. The thematic analysis showed that the VR media productions utilized limited framing and contextualization of the issues pertaining to climate change — as opposed to the broad multidisciplinary approach that the IPCC report takes and offers as a framework to help people understand the gravity of the problem caused by climate change. The study extends the theoretical understanding of the role VR plays in highlighting the climate crisis and provides practical implications on the uses of VR for climate change storytelling and reporting.

Further, exploration in this area of research using mixed methods and data triangulation through quantitative data collection such as self-report surveys and qualitative semi-structured interviews would extend the understanding of the role of VR in climate change storytelling and pro-climate action. Another exploration can use the theoretical framework of experientially-meaningful communication or ambient communication (Wijaya, 2011) to analyze the sensory, emotional, rational, benefit, relevance, and social aspects of VR media experience.

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